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Engrav'd for the General Magazine of Arts & Sciences for W. Owen at Temple Bar 1756.

40877

THE
Young Gentleman and Lady's
PHILOSOPHY,

IN A

Continued SURVEY of the WORKS of
NATURE and ART;

By Way of DIALOGUE.

VOL. I.

CONTAINING,

The PHILOSOPHY of the HEAVENS, and of the
ATMOSPHERE.

Illuſtrated by Thirty-three COPPER-PLATES.

By BENJAMIN MARTIN.

LONDON:

Printed and ſold by W. OWEN, *Temple-Bar*, and by the
AUTHOR, at his Houſe in *Fleet-ſtreet*.
MDCCLIX.

40877

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An Account of the PLAN and DESIGN of this MAGAZINE.

AS the higheſt Attainments of the human Mind conſiſt in uſeful Knowledge, the Perfection of our Nature can only reſult from thence; and, in order to promote that in the greateſt Degree, we muſt render the various Arts and Sciences as eaſy of Acceſs, or the Pathway to Knowledge as direct and plain, as poſſible: And this, in ſhort, is the Deſign of our preſent Publication. To effect which we ſhall employ our Time and Abilities in the beſt manner we can, and therefore preſume that the Public, who are ever candid and ingenuous, will want no other Inducement to a good Opinion, and favourable Reception, of ſuch an Undertaking.

But tho' the Merit of a Deſign may be indiſputable, yet the manner of executing it is a Thing very material, and therefore we ſhall here at large lay it before the Reader; ſince it too often happens that the Expectation of the Public is mightily rais'd by Title-Pages, Propoſals, *&c.* but immediately ſubſides upon reading a few firſt Sheets of the Performance.

Our Purpoſe is to compile and preſent our Readers with *a real and general Magazine of Arts and Sciences:* Concerning which it is to be obſerved,

Firſt, That the Undertaking is in itſelf a Work entirely new; for though the Preſs has long groaned under the Weight of Magazines of various Complexions, not one of them has appeared with any Pretenſions of this Kind, moſt of them being calculated for Amuſement only; and as to the reſt, if the Words Arts and Sciences are found in their Title Pages, you ſeek in vain for the Things themſelves, in the Body of the Work; or if any Thing of that Sort appears, it is only by Peace-meal, in Bits and Scraps, disjointed and mangled, without Order or Connection, and therefore of no Uſe to any one. On the contrary, in our Magazine we propoſe a compleat Body of *real* Arts and Sciences; for I diſtinguiſh between thoſe that are *truly and really* ſo, and thoſe that are not: Since it is well known that many Subjects have been uſhered into the World under the reſpectable Names of Arts and

Sciences, to the great Abuſe and Deluſion of Mankind. Thus, formerly, the blaſphemous Jargon of *Aſtrology* was dignified with thoſe Epithets; and many other Subjects are deemed Sciences, but are falſely ſo called, as they convey no real Knowledge to the Mind.

Secondly, The Form of our Work is intirely new; for a Body of *Arts and Sciences* has never yet been attempted in any monthly periodical Publication, under the Title of a MAGAZINE. And this Form we rather chuſe, not only as it ſuits with the Humour and Taſte of the preſent Age, but alſo becauſe it will be the eaſieſt Way to communicate Subjects of this Sort, and attended with leſs Expence and Trouble as well to the Publiſher as the Reader; not only ſo, but a whole Body of Arts and Sciences poured out on the Public at once, might not perhaps be quite ſo pleaſing and acceptable, as when retailed out in monthly Portions; for now a Perſon cannot think one Half-ſheet upon a Science in a Month too much, as he will have Time enough to read and digeſt that before another comes to Hand, even in the more abſtruſe Arts, that require ſome Study and Attention: and ſince it will be in vain to crave for more than there can be Time to peruſe and underſtand, it is preſumed, that what has been now ſaid, may be a ſufficient Anſwer to an Objection that may poſſibly be made againſt a monthly Publication,— That it will be too ſlow, or tedious, a Performance; but we ſhall make no Scruple to ſay, that admitting a Perſon has a good Genius he will be allowed to make a great Proficiency if he can make himſelf Maſter of the uſeful Arts and Sciences in the Compaſs of *Ten Years*.

Thirdly, There has been no compleat Syſtem, or Body of Arts and Sciences ſince the new Diſcoveries, and great Improvements in all the Branches thereof made in the laſt and preſent Age.

The Face of Philoſophy is entirely new, and a new Geometry has ſucceeded the old, which occaſions a general Renovation in all the Mathematical Sciences; the moſt ſubſtantial and ſolid Parts of Learning have therefore now a new Aſpect, and wear quite a different Dreſs from what they uſed to appear in. A general Syſtem of the Sciences, attended with ſo much Novelty and Utility, cannot now, we hope, but be very grateful to every Lover of Art and Friend to Learning.

Fourthly, The Novelty of our Method we may reaſonably ſuppoſe will be another Argument to recommend it, ſince our Plan is to carry on the four great Claſſes of Science at once. Variety never fails to pleaſe in other Caſes, and here it muſt have all its Force, ſince every Half-ſheet of our Magazine will be pregnant with new Principles of Knowlege, and every Number will preſent the Reader with a gradual Progreſs of the Sciences, proceeding Hand-in-Hand; when he has conſidered the Subject of one he may apply himſelf to another, after that to a third and fourth, all different from each other, and each in particular ſuch, we preſume, as will be worthy his Attention, and afford him Pleaſure and Inſtruction at the ſame Time. After this, by Way of Relaxation and Amuſement, in the fifth and ſixth Half-ſheet, we ſhall preſent him with ſome of the choiceſt Pieces of Learning, Wit, Humour, Poetry, News, *&c.* all which we judge will be ſufficient to fill up the vacant Hours of each reſpective Month.

Fifthly, Another great Inducement to this Undertaking is, the ſatisfactory Proſpect we have of making the Arts and Sciences more generally known and uſeful to Mankind; for Experience forbids us to expect that a general Publication of the whole at once, would ever fall into ſo great a Number of Hands as it probably may this Way, it is not conſiſtent with Prudence, in any Caſe, to overdo a Thing; People ſhould be gradually conducted from one Apartment to the other in the Temple of Science, for ſince one ſimultaneous View of the Whole would rather tend to confuſe than inſtruct the Mind, and deter from, rather than invite to, a particular Examination of the Parts: Things, though ever ſo good in themſelves, by too great and ſudden a Profuſion, inſtead of exciting a Curioſity and Inclination, would probably create an Averſion, if not a *Nauſea* thereto. And therefore to avoid any tendency to diſcourage the Study of the Sciences, we have thought it by much the beſt Way, to proceed in the Method of our preſent Plan.

We proceed now to give ſome Account of the Subject Matter of the Work:

I. The firſt Part will conſiſt of a general Survey of the Works of Nature and Art, that is to ſay, we ſhall take a particular View of the ſeveral *Phænomena* of Nature, as they ariſe from the various Subjects that fall under our Obſervations, in the Heavens, the Air, the Earth, and Water, which we ſhall repreſent, illuſtrate and explain by the ſeveral Inſtruments and Machines which Art has invented, or can ſupply for that Purpoſe, and that in the moſt eaſy and natural Manner, ſo that the Truth and Reality of the

Nature and Cauſe of thoſe Appearances may be rendered quite obvious to the Underſtanding; for in this Part we ſhall propoſe nothing but what we may reaſonably ſuppoſe all our Readers can underſtand: and in order to do this more effectually we ſhall propoſe it in the common Way of Experiments, ſince it is found by general Experience the beſt of all accommodated to convince the Underſtanding, as it conſiſts in little more than an Appeal to the common Senſe of Mankind. We oftentimes expreſs great Diffidence with reſpect to our intellectual Faculties, but few People are ſo fooliſhly modeſt as to diſtruſt their Senſes in Caſes where Objects are propoſed to them in a proper Manner; and ſince the Senſes are the general Inlets and Means of Knowledge, and are formed as accurately and juſt as perfect, in one Sex as the other, therefore theſe philoſophical Subjects muſt be, in this Way, equally intelligible to both; conſequently the LADIES may be admitted to the Pleaſure and Advantage of theſe Speculations as well as Gentlemen, if not with more Reaſon, ſince Gentlemen have generally an Opportunity of coming to the Knowledge of theſe Things, in a way different from that of the Fair Sex: And therefore we have propoſed it in Dialogues between a young Gentleman and a Lady in the natural and eaſy Way of Converſation; by which Means we hope the Inſtruction will be more eaſily conveyed, and attended with much greater Pleaſure than in the common dry and tedious Dialogues heretofore written on theſe Subjects. Moreover, the Inſtruments and Machines themſelves will be very particularly deſcribed, and many new ones introduced, with their Advantages and Excellencies pointed out; alſo Copper Plates and Diagrams will be ſupplied where ever they are wanted for Illuſtration. *Laſtly*, to render the Whole as compleat as poſſible, we ſhall frequently embelliſh the Subject with the moſt beautiful Deſcriptions, Alluſions, and Similies that can be found in the moſt celebrated antient and modern Poets, ſo that upon the Whole we hope we may be allowed, with great Propriety, to give this Part the Title of the YOUNG GENTLEMAN AND LADY'S PHILOSOPHY.

II. The ſecond Part of our Work will conſiſt of an entire Syſtem of the natural Hiſtory of the World, or ſo much of the Knowledge of the natural Productions of the Earth and Sea as we have hitherto been able to diſcover; and here our Subject will naturally divide into ſeveral general Heads, *viz. Firſt*, the Situation,

tuation, Extent, Soil, Produce, Climate, Air, Length of Days and Nights, *&c.* of each reſpective Country, the Diſpoſition and Genius of the Inhabitants, their Cuſtoms, Manners, Language, *&c. Secondly*, every thing remarkable in, and peculiar to each Country, with reſpect to their Beaſts, Birds, Reptiles, Inſects, and Fiſhes in the Seas contiguous. *Thirdly*, their Mountains, Springs, Rivers and mineral Waters. *Fourthly*, every thing conſiderable in regard to vegetable Productions, relating to Trees, Shrubs and Plants. *Fifthly*, Mines, Ores, Minerals, Foſſils, Marcaſites, Stones, Earths, Marls, *&c.* in ſhort, every thing that Hiſtory and our own Obſervations can furniſh, deſerving the Reader's Notice, relating to the Animal, Mineral, and Vegetable Kingdoms. Upon theſe Subjects we ſhall conſult only ſuch Authors whoſe Veracity and Credit is unqueſtionable, and where ever the Narrative is wonderful we are ſatisfied it is true; and this we ſhall be particularly careful about, as it is but too well known how much the World has been impoſed upon by fabulous and falſe Accounts of Things in the Writings of antient and modern Naturaliſts; things enough will be found, not only to amuſe our Readers but to excite their Admiration and Surprize, without having recourſe to the low Arts of Impoſture, Frauds and Falſity. Upon the Whole we ſhall endeavour to preſent the Reader with ſuch a Body of natural Hiſtory, both of our own and other Countries, as ſhall have nothing but the Marks of Simplicity and Truth to recommend it.

III. The third great Part of our Plan is intended to conſiſt of a compleat Body of Arts and Sciences which are not Mathematical, ſuch as *Natural Theology*; *Ethics*, or *Morality*; *Revealed Religion*; *Paganiſm*, *Mythology*, *Grammar*, *Rhetoric*, *Logic*, *Metaphyſics*; *Poetry*, *Geography*, *Chronology*, *Hiſtory*, *Phyſiology*, *Botany*, *Chemiſtry*, *Pharmacy*, *Phyſic*; *Anatomy*, *Mineralogy*, *Metalurgy*, and many other Branches of manual and commercial Arts, Trades, and Manufactures.

Theſe different Kinds of Knowledge we ſhall treat of in the moſt natural, methodical and conciſe Manner, according to the moſt approved Authors, and the beſt Theories that our preſent State of Learning will furniſh, and ſhall venture in many Places to make no ſmall Innovations, by adding many things new and retrenching all the ſuperfluous Parts of the old Syſtems; and by this Means ſhall endeavour to exhibit every Science in its proper and native Light: They will here no longer appear in their dry ſcholaſtic Forms, but in all the beautiful Simplicity that the genuine Principles of real Science can give them. We need not here expatiate on the Utility of theſe Branches of Knowledge, ſince it is well known that, in all Ages, and in every Nation, they have made the principal Part of Learning, diſtinguiſhed by the Title of the *Belles Lettres*, though far ſhort of that Perfection to which they have attained in the preſent Age, and in our own Nation in particular, theſe Sciences ſtill farther recommend themſelves by the Plainneſs of their Principles and being ſo eaſily underſtood; particular Talents for other Sciences are required, but theſe are equally adapted to every ingenious Mind, and ought to be the Study of the *Gentleman* as well as the *Scholar*, ſince they make the great and ſubſtantial Part of what we properly underſtand by a polite and genteel Education. In the laſt Place it muſt be obſerved, that theſe Sciences are not only uſeful to Mankind in general, but many of them ſuch as are abſolutely neceſſary; for what is Man without the Knowledge of Religion? Without the inſtructed Faculty of Reaſoning? Without the Art of ſpeaking properly and writing gracefully? Without the Knowledge of paſt Times and Events? Or without Skill in the fundamental Arts and Profeſſions? From all which we may juſtly infer, that theſe are ture and real Sciences, and greatly dignify human Nature.

IV. The fourth great Part will conſiſt of a continued Series of mathematical and mechanical Inſtitutes or Principles of geometrical Science, beginning with thoſe that are the moſt ſimple and eaſy, and proceeding to the more compounded and ſublime: our Readers therefore will excuſe our preſenting them in the firſt Place with the Rules of common Arithmetic, Vulgar and Decimal, as they are the firſt Principles of all mathematical Science; we then ſhall lay down a Compendium of Logarithms, whoſe Uſes are well known to every ingenious Philomath; after theſe follows the Analytic Art, or the Principles and Rules of *Algebra*, then the Theorems and Problems of *common Geometry* in a new and conciſe Method; we ſhall then deliver the Properties of the *Conic Sections*, viz. the *Ellipſis*, *Parabola* and *Hyperbola*. To this will ſucceed the Doctrine of the Sphere, or the Principles of ſpherical *Geometry*. After this we propoſe an extenſive View of the new Matheſis, which may properly be called the Newtonian *Geometry*, as it principally conſiſts in the *Doctrine* of FLUXIONS, which was entirely the Invention of Sir *Iſaac Newton*, and from which the mathematical Sciences received their higheſt Perfection and their final Improvement. From the Inſtitutions of *common Geometry*, conſidered as the Theory, we ſhall deduce a regular *Praxis*, or Syſtem of mathematical Sciences, ſuch as *Menſuration* of *Superficies* and *Solids*; of Heights, Depths and Diſtances; *Gauging*; *Surveying*; *Navigation*, in ſeveral Kinds, plain and *ſpherical Trigonometry*; the Rules of *Perſpective*; Projection of the *Sphere*; the Art of *Dialing*; *Aſtronomy*; the Principles of *Mechanics*, &c. with a practical Application in all the uſeful Parts of Buſineſs. And from the Inſtitutions of the *New* or *Fluxionary Geometry* we ſhall give the Solution and Application of all the grand Problems relating to the Quadrature of curvilined Spaces, the Cubature of Solids, the Rectification of Curve Lines; the Method de *Maximis* and *Minimis*, of drawing Tangents to Curves; of finding the Radius of Evolution; of finding the Points of Inflection and Retrogreſſion in Curves; of finding the Centers of Gravity and Percuſſion; the Laws of Elaſtic and Non-elaſtic Bodies; of the Velocity, Times and Spaces deſcribed by Bodies in Motion; the Laws of Reſiſtance in Fluids; the Doctrine of circular Motions and central Forces; the Doctrine of Projectiles in *Vacuo* and in reſiſting Mediums; the Theory of Catoptrics and Dioptrics; the phyſical Part of Aſtronomy, and various other Subjects, which only this Sort of Geometry can reach, all which will be treated of in as plain and eaſy a Manner as the Nature of them will admit, and in a Method in many reſpects quite new.

V. The Thing we have next in View is to entertain our Readers with every thing curious and worth their Notice, communicated by any ingenious Correſpondent, whoſe Lucubrations or Eſſays in any Branch of Science, Wit, Humour, or Buſineſs, will be acceptable and thankfully received for that Purpoſe; many things in a miſcellaneous Way may by this Means be convey'd with great Advantage to the Public; the Divine, the Mathematician, the Philoſopher, the Gentleman, the Ladies of *Helicon* and *Parnaſſus*, the Critic, the Hiſtorian, the Antiquarian, the Merchant, the Mechanic, and the Manufacturer, may here find an Opportunity every Month of communicating their Thoughts for the Entertainment and Inſtruction of Mankind; and every ſuch Contributor ſhall have the Credit and Honour of his Invention and Performance ſecured to him by affixing his Name thereto if he chuſes it, and though we ſhall take Occaſion now and then to tranſcribe ſuch Things as we think proper for our Purpoſe from Pieces already in print, we ſhall at the ſame Time take particular Care to let the World know to whom they are indebted for it.

VI. In the laſt Place, our Magazine will conclude with an hiſtorical and chronological Memoir of all public Events of the paſt Month worthy Notice; the State of our own and other Nations will here appear; the Births, Marriages, Promotions, Deaths, *&c.* of all illuſtrious Perſons, will be commemorated as well as the great Actions and Virtues that raiſed them to Public Notice, and diſtinguiſh them from the reſt of Mankind. A regular Account of Books publiſhed Abroad and at Home, with a ſhort Account of the Contents of ſuch as deſerve it. The Prices of Stocks and Goods at the *Keys* in *London* and Country-markets, with every other important Article of public Intelligence.

To conclude, no Expence of Copper-plates, Diagrams, or Cuts will be ſpared for illuſtrating the ſeveral Parts of this Work, nor will the Public be troubled with any that are trivial or uſeleſs. The Materials for this Work have been long compiled and often reviſed and altered—we hope for the beſt. In many Parts of the Work the Reader will meet with the Generality of Inſtruments either quite new or differently conſtructed from thoſe hitherto publiſhed. The ſubject Matter in many Places is alſo quite new, as well as the Method of repreſenting it. The Pages of each Half-ſheet will be properly numbered for binding up each reſpective Subject. In ſhort, the Whole will be a compendious View of the Learning of the preſent Age in all its numerous Branches, which we ſhall conſtantly endeavour to execute to the beſt of our Abilities. To conclude, That nothing may be wanting to make every thing agreeable as well as uſeful, a new and elegant Letter has been caſt for this Work, good Paper provided, and the beſt Engravers engaged. We hope every future Number will convince the Public we aim at the greateſt Perfection that can poſſibly be attain'd to in ſuch a Work, and we deſire their Acceptance of our Labours only in Proportion to the Merits of the Performance, which will ſufficiently recompence their

Moſt Obedient,

Humble Servant,

B. MARTIN.

PREFACE.

WE do not here propoſe to give a general Preface, or complete Title Pages to the Work; but ſuch only as may anſwer the Purpoſe of thoſe that are inclined to bind up the ſeveral Parts ſeparately at the End of ſix Months. In two Years more there will be a complete Volume on each Subject of the four firſt half Sheets, which will then appear with all the proper Furniture, viz. complete Title Pages, Preface, Table of Contents, *exact* Indexes, *Tables of* Errata, *&c. thoſe which we give at preſent being then to be cancelled by the Book-binder.*

It is now our Duty to acknowlege, with the ſincereſt Gratitude, the unexpected Favours we have received from the Public, in accepting ſo generouſly, and promoting ſo large a Sale of our Magazine of Arts and Sciences, as no one before had ever the Honour to boaſt of at the Commencement of the Work. We have the Satisfaction to find our Plan is greatly approved on from every Quarter; but it would look like Vanity to publiſh to the World the numerous Encomiums that we have conſtantly ſent to us by our ingenious and worthy Subſcribers, Correſpondents, and Friends. The Succeſs of our Work we muſt impute principally to the extreme Uſefulneſs of the Subject Matter, and the good Senſe and Diſcernment of our Readers, who muſt be allowed the public Patriots of Learning. *On this Account alſo we hope we have a grounded Expectation of the Continuance of it, eſpecially as the Subjects of each Part will, for the future, admit of a greater Variety of uſeful and intereſting Matter than thoſe of the firſt Year could do, particularly in the philoſophical and mathematical Parts, which have hitherto been employed chiefly about the Elements of the Sciences; but theſe, for the Time to come, will contain a very great Variety of Principles and Propoſitions which conſtitute the moſt eſſential Part of that Knowledge which has always been allowed to be of the greateſt Importance, and to conduce moſt immediately to the Emolument and Happipineſs of Mankind. We dwell not ſo much on the leſſer Arts of Embelliſhment and Decoration, tho' theſe will never be wanting nor any Expence ſpared when they can be introduced to give any Advantage to the Reader. We preſume however that the* Novelty *and* Variety *of the Sub-*

jects treated on in this Work, will plead ſome Merit. As no one has ever attempted any Thing in this Way before, and as we write, not only for the preſent, but future Times, the Uſefulneſs of our Undertaking is more evident and univerſal; our Subjects are not the Trivia *of the Times, the* common Place *of* News, *low* Witticiſms *and vulgar Amuſements, theſe are ſerved up only as a Deſert upon Occaſion; but the Themes of our Diſſertations are the lofty and important Subjects of human Knowlege, a* Body of Arts and Sciences *which no one can look upon with Indifference, as Truth has been always the Purſuit of Mankind as their* Sumum Bonum, *and will always remain unchangably the ſame, and therefore* our Magazine *will always be of the ſame Uſe it now is. The* Sciences *are not* annual Plants, *or* Muſhroom *Productions, which appear for a Time and die away, but they are* Ever-greens *of eternal Duration;* Trees *of real* Knowlege, *whoſe Fruit inſpires the juſt Notions and Sentiments of* Good *and* Evil: *No Wonder then if they are admired and cultivated by Men of Senſe and a ſuperior Turn of Mind; and in ſuch a Nation as* GREAT-BRITAIN, *renown'd for Learning and the Encouragement of Arts, above all others of the habitable World.*

B. MARTIN.

ON THE USEFULNESS OF NATURAL PHILOSOPHY:

A POEM.

Hoc ſtudia adoleſcentiam alunt, ſenectutem oblectant, ſecundas res ornant, adverſis, ſolatium, et perfugium prebent; delectant domi, non impediunt foris, pernoctant nobiſcum, peregrinantur, ruſticantur. Tull.

O THOU! Enthron'd above the ſtarry Orbs,
Great Cauſe *of Cauſes! Everlaſting* God!
Aſſiſt a grov'ling Worm, who feebly tries
To ſing thy mighty Works in grateful Verſe:
O, let a Spark of that celeſtial Fire,
Which touch'd Isaiah*'s Lips, influence mine!*
While Chaos *reign'd, and Darkneſs cloth'd the Deep,*
Th' ætherial Spirit *hover'd o'er its Maſs.*
Hark! From the Slumbers of Eternity,
Forth from the great Eternal*'s bright Abode,*
Let there be Light! *The ſacred* Fiat *rung,*
And all around Light inſtantaneous roſe!
With equal Might, in ſix ſucceſſive Days,
The Sov'reign Architect *his Work perform'd;*

The Seventh beheld the new Creation ſmile ;
Then reſted GOD *from all his glorious Toil.*——
High in the Vault of Heav'n, the central Sun
Superior ſhone, in radiant Luſtre dreſs'd,
With native Heat to great Degree endow'd,
And ſmil'd on frozen Saturn's *diſtant Ring :*
Himſelf a World, amidſt ſurrounding Worlds !
About him, all the planetary Train
Joyful, began their new harmonious Dance.
In ſtated Periods next the Comets *mov'd,*
Large, ſolid Bodies, with a Length of Tail ;
Elliptical, and various in their Courſe,
Still more, or leſs attracted by his Heat.
Earth *on her Center mov'd from Eaſt to Weſt,*
The Third *amidſt the wond'rous* Syſtem *plac'd ;*
In all her gayeſt Drapery adorn'd,
To ſtrike the Eye, and captivate each Senſe ;
And round her mov'd the Moon's *officious Light.*
Birds, thro' extenſive Fields of liquid Air,
By quick Tranſition, ſported on the Wing,
And ſung in various Notes their Maker's *Praiſe.*
The Streams prolific pour'd the finny Race,
While mighty Ocean *with new Monſters teem'd ;*
The Whale, *with Bulk enormous to behold,*
Behemoth, *and the great* Leviathan,
With ev'ry Species of the rolling Deep.
Beaſts of a thouſand Kinds then trod the Plain,
Reptiles and Inſects ſhone in gay Attire,
Ting'd with unnumber'd gloſſy Dyes, that prov'd
Shade above Shade, the Painter's *matchleſs Art.*——
Man *then was form'd, as ſov'reign* Lord *of All,*
More fair and wiſe than all the brutal Train,
With Soul divine endow'd, ſtupendous Frame,
Godlike, erect, with Reaſon *for his Guide ;*
Reaſon, *the Gift of great indulgent Heav'n !*
This dignifies the Man *beyond the* Brute ;
This bids him hold ſweet Converſe with the Skies !
He, with his Talents, and ſuperior Senſe,
Thro' Nature *takes a philoſophic View,*

While Wonders, rais'd on Wonders, ſtrike his Eyes!
If yon vaſt Vault demand his earneſt Search,
There Symmetry, magnificently great,
Form'd by unerring Wiſdom ſtands confeſs'd;
Where Worlds on Worlds in ample Order ſhine
Thro' all the boundleſs Tracks of Univerſe.
Two Principles *endow the Soul of Man,*
His Underſtanding, *and his better* Will:
That, thro' a Thirſt of Knowledge he perfects,
This, by his Goodneſs, more ennobled ſhines:
Nothing below can more enlarge the firſt,
Or raiſe the laſt, than ſtudying Nature's *Rules*;
Rules, which obſerv'd, will lead to Nature's GOD.
O Man! *His much-belov'd, his darling Care,*
Ne'er let the Gifts He *plenteous pours around*
For thy Delight and Uſe, be pour'd in vain:
Let ev'ry Morn thy Gratitude aſcend!
Would'ſt thou be rich?——Laborious dig thy Gold,
Dig Truth, dig Wiſdom from the latent Mine;
Then coin, and uſe them for thy proper Uſe:
If ought to ſpare, beſtow on human Kind,
And kindly ſhew them how to ſearch for more.
This ſhall advance thee o'er the vulgar Crowd,
And claim Reſpect among the Sons of Men.
All hail PHILOSOPHY! *Celeſtial Fair!*
Sent from above, replete with ev'ry Good,
T' improve each ſtriving Faculty within,
To mend our Morals, and refine the Heart.
Without thee, what were thoſe reſplendent Orbs,
With all the grand Appendage of the Skies?
Thoſe Stars, that twinkle in the vaſt Expanſe,
From thy Aſſiſtance more conſpicuous ſhine;
Silent they teach a Leſſon to Mankind,
And light us on to Scenes of future Joy.
For Fruits of Knowledge, oft th' enraptur'd Mind
From Field to Field of Contemplation roves,
And forms from cloſe Purſuits more gen'ral Laws;
Laws, which the great Phænomena *explain*
Of Earth, Sea, Air, and Regions far above;

She cancels Limits——glowing now aſcends
From Scale to Scale of Beings, 'till ſhe ſoars
In Thought profound, beyond Creation's Bounds,
"*To the firſt good, firſt perfect, and firſt fair.*"
From Stage to Stage, now gradual ſhe deſcends,
Beneath ambroſial Dews, the Gift of Heav'n!
Beneath the loud Applauſe of Angel-Hoſts,
And lights again on this terreſtrial Sphere.
Whether this ſpacious Earth we traverſe o'er,
Or rove in Thought from Indus *to the* Pole;
Whether we mount contemplative the Skies,
And journey thro' Plurality of Worlds;
Which Way ſoe'er our darling Genius leads,
We view the Footſteps of the DEITY!
What rigid Sceptic *boldly ſhall deny*
Philoſophy's *of gen'ral Uſe to* Man,
When by its Study, he more clearly knows
The Wiſdom, Pow'r, and Attributes of GOD?
The Miſts of Error puzzle Men no more,
Such as prevail'd, when dawn'd the myſtic Art;
Experience long all Darkneſs has remov'd,
And Truth breaks round us with reſiſtleſs Blaze.——
Shall We, the nobleſt of Creation's Works,
From Year to Year ſupinely ſpend our Time,
Nor once indulge a ſcrutinizing Thought,
How Nature, *pregnant with all Life can crave,*
Preſerves, throughout, one great, harmonious Round?
To ſearch her Ways will more Contentment yield,
More laſting Pleaſures, more exalted Joys,
Than all the Stores the great Peru *can give,*
Or precious Diamonds from Golconda's *Mine.*
Thro' Life's ſhort Courſe, what trifling Toys amuſe?
Fraught with no bleſs'd Advantage to the Mind;
Tho' ever ſtudious to enhance Delight,
And ev'ry Day Diverſion ſhifts the Scene:
Each Novelty grows languid in our Eyes,
While full Fruition palls upon the Senſe;
Beauties there are, which more refin'd can pleaſe,
Which in more delicate Succeſſion riſe

From Wiſdom's *chaſte Embrace, and ſtricter Rules*;
Such as attend us thro' this dreary Vale,
Nor leave us, 'till we leave terreſtrial Things.
In Youth they firmly fix our wand'ring Thoughts,
And ſtamp the beſt Ideas on the Mind;
Add Luſtre to the Paths of middle Life,
Glow in the Boſom of the hoary Sage,
Crown with illuſtrious Worth his rev'rend Head,
And make him ſmile ſerene at Death's Approach.
Thro' various States Proſperity adorn:
Retreat and Comfort bounteouſly beſtow,
When ſtern Adverſity tremendous frowns.
Delight at Home, nor e'er diſguſt abroad;
They travel with us to remoteſt Climes,
Make ev'ry Country yield a Tide of Joy;
Attend thro' ev'ry Office of the Day,
And when the Night returns, with us repoſe.
Innumerable Uſes flow to Man,
Thro' ev'ry Branch of circulating Trade,
From the juſt Lights which Nature's *Plan affords.*
With arduous Toil th' Aſtronomer *acquires*
The Frame of Heav'n, made eaſy to his Sight;
He views the vig'rous Sun's *meridian Blaze,*
The Moon, *and ev'ry* Star *that gilds the* Pole.
From hence, the Merchant, *emulous of Wealth,*
At proper Periods, truſts the raging Seas;
Knows when the Winds will gently ſwell the Sails,
When bluſt'ring Boreas *ſleeps within his Cave,*
And either India's *Stores become his own.*
The grave Phyſician, *by cloſe Study, finds*
The healing Virtues and Effects of Plants,
With all the Tribes of medicable Herbs.
With equal Care, the Chymiſt *too attains*
The Uſe of Metals, Min'rals, and their Stores,
Prepares, diſſolves, and analyſes All.
Th' Apothecary *happily explores*
The various Simples *of the fertile Field,*
And calls, by niceſt Rules, his Antidote,
To form his Med'cines, and reſtore Mankind.

The poor Mechanic, *with Attention due,*
His Myſt'ries may enlarge, and gain Applauſe,
And with Applauſe, perhaps attractive Gold.
Led by her Laws, the Huſbandman *may learn,*
At proper Times, to fertilize his Lands,
And make his Acres yield an hundred-fold,
A golden Crop, from Ceres' *lib'ral Hand.*
In ſhort, look ronnd this habitable Globe,
View Kings *and* Princes *more illuſtrious ſhine,*
Charm'd with the Virtues *of* Philoſophy !
From Stations high, by juſt Degrees, deſcend,
Thro' ev'ry State ſubordinate to Life,
What Man of Reaſon but adores the Maid ?
For Reaſon ſtill attends her ev'ry Hour,
Thro' ev'ry Region where ſhe takes her Flight,
Soars when ſhe ſoars, and with Devotion glows.
PHILOSOPHY ! *Sure Guide to limpid* Truth,
Choice of the Wiſe, *a Myſtery to* Fools,
Who blind with Ign'rance, ſcorn thy winning Smiles.
In Ages paſt, thou rear'dſt thine honour'd Head,
A-while imperfect known——'till rolling on
With ſmall Improvement down the Stream of Time,
Thy Features more refin'd, and lovely grew :
Finiſh'd at length by Newton's *plaſtic Hand,*
Philoſophy *commenc'd a finiſh'd* Fair,
Adorn'd with ev'ry Beauty, Grace, and Charm,
To win obedient Hearts, and gain Applauſe.
O, more and more extend thy gentle Sway
O'er Virtue's *favour'd Race, and bleſs Mankind !*
Make ev'ry Fair *who crowns* Britannia's *Iſle*
Enamour'd with thy Charms, ſtill fairer grow ;
O, raiſe an Emulation, truly great,
In ev'ry Art each other to tranſcend !
On either Sex *kind* Nature *has beſtow'd*
A juſt Proportion of indulgent Parts,
And form'd alike Competitors for Praiſe :
From Education only, Men are found,
By Cuſtom taught, to claim ſuperior Senſe :
Riſe, zealous riſe, aſſert your native Rights,

Thro' Nature's *Volume diligently pry,*
And claim with us an equal Share of Fame.
What great, what glorious Properties has Light !
Bleſs'd Emanation of th' Almighty Pow'r !
The firſt material Link in Beings Chain !
Worthy the Fiat, *that firſt call'd thee forth*
From Darkneſs, and Confuſion's wide Domain !
Attracted by thy Pow'r, the raviſh'd Eye
Deſcants on all around with vaſt Delight ;
The Soul exults amid her wond'rous Frame,
For Man's *the wond'rous Workmanſhip of* God !
Auſpicious Light ! *be friendly to Mankind ;*
Long o'er the Products of this fertile Globe
Diſplay thy Charms, 'till Time ſhall be no more.
What various Dyes on Trees, Herbs, Fruits, and Flow'rs,
Thy Rays refracted, beauteous pour abroad !
Light *to the Peach imparts the Bluſh it wears,*
Tinges the Nect'rine with a deeper Red,
Beams on the Plumb that ſoft, inviting Blue,
And o'er Pomona's *Gifts pours countleſs Charms :*
Paints ev'ry Colour in the Peacock's *Tail,*
With ſplendid Iris, *that celeſtial Bow.*
How pow'rful proves the Air's *elaſtic Force !*
As on the Pump Experiments confeſs :
Creation's Fruits no more could vig'rous thrive,
Than Man ſubſiſt without the fragrant Balm.
Porous are all the vegetable Tribes,
And all receive freſh Draughts of vital Air,
By juſt Gradation to the royal Oak,
Or Cedar, which adorns the Mountain's Brow.
Our Atmoſphere all pond'rous preſſes round
In ſtrict Proportion o'er the Face of Things,
Yet all ſuſtain the vaſt, ſurpriſing Weight,
Buoy'd by Reſiſtance of internal Air.
The Winds from Vapours purge th' aërial Climes,
Which, otherwiſe, would taint both Man and Beaſt.
What Care has that Almighty Mind *beſtow'd*
On theſe, his lower Works, Works all Divine !
How worthy our Inſpection and Regard !

Let Pride abaſh'd, ſink humbly to the Duſt,
When we behold the ſame tranſcendent Skill
At large diſplay'd thro' Nature's *ample Field,*
As in this glorious, fair Machine of Man.
Sing next, my Muſe, *what Uſes flow from* Sound,
Whoſe Medium is the wide circumfluous Air;
Caus'd by ſome ſudden Stroke, the quav'ring Parts
Affect the Tympanum, and ſtrike our Ears.
How ſoft, how pleaſing to th' attentive Mind
Are Notes, ariſing from melodious Strings!
Artful they ſooth our Troubles into Reſt,
And waft the Soul beyond her native Sphere.
So David *pleas'd the royal Ear of* Saul,
Baniſh'd all Diſcontent, all anxious Thoughts,
And pow'rful made the Snakes *of* Envy *ſleep.*
Tarantulas *in vain envenom'd bite,*
If Muſic's *ſov'reign Antidote oppoſe:*
By juſt Degrees, th' afflicted Patient feels
No more a Numbneſs of his nat'ral Parts,
Enliv'ning Airs *affect his whole Machine,*
His Legs, Arms, Fingers, catch the thrilling Sound,
With Joy he bounds, to perfect Health reſtor'd.
From Concords, *ſuch great Benefits ariſe,*
And ſuch the Goodneſs *of the great* Supreme!
What Pow'r has Gravity! *What mighty Force!*
By which all Bodies to their Center tend;
The Sun *attracts the* Planets *in their Orbs,*
This Globe pale Cynthia *gliding in her Sphere:*
All teeming Matter gravitates to Earth,
Towards her Bowels, where her Center lies:
On ev'ry Form it acts with equal Force,
As much on Feathers as more pond'rous Gold!
What Qualities the uſeful Magnet *yields,*
Which conſtant points the Needle to the Pole,
Unleſs betray'd by ſubterranean Ore!
Without the Loadſtone's *neceſſary Aid,*
The Mariner *in vain would plow the Deep,*
In queſt of foreign Ports, in foreign Lands.
How great the Pow'r, the Wiſdom, and Deſign,

Of One *almighty, all-creating* God !
Who form'd this World ſo uſeful and ſo fair,
And from her Entrails gives ſuch precious Gifts.
What various Scenes all wonderful ariſe
From the Purſuit of Electricity !
An Art well worthy of the greateſt Praiſe ;
Improv'd by Moderns thro' a length of Years.
Like ſome fair Science *now ſhe lifts her Head,*
And claims a Volume to record her Uſe.
Great Truths have lately been diſclos'd to Light,
While undiſcover'd lie ten Thouſand more,
Which Time and Study beauteous may unfold,
And publiſh wide their Virtues to Mankind;
On Themes like theſe the Muſe *could much enlarge,*
T' enforce the Study of great Nature's *Laws,*
And prove its Uſes to the human Race ;
But Time contracts her Song, and damps her Flight :
A Chain of Subjects muſt remain unſung,
Fraught equal with the great Creator's *Pow'r.*
Here, let ſome Fav'rite of th' Aionian Maids
Aſſume the Theme, with Zeal divine impell'd ;
While I, inſpir'd with Gratitude and Love,
With this Addreſs conclude the ſacred Song.
Creation's Lord ! *Great* Nature's *glorious Guide !*
Who ever wakeful, from thy bleſs'd Abode,
With piercing Eyes ſurvey'ſt each dawning Thought,
E're brought to Speech, and flowing from our Lips :
Attend thine Ear a-while to ſuppliant Duſt,
Duſt form'd by Thee, *and form'd indeed divine !*
When Inclination prompts with warm Deſires
To ſearch this Fabrick of the lower World,
Direct, auſpicious Guide, *our Search aright !*
Or when we ſtrive to ſearch the Heights above,
Curious to trace thy more ſurpriſing Works,
Thou *light us on to thoſe celeſtial Scenes,*
Where Beauty, Order, Harmony conſpire
To raiſe Devotion, and exalt our Love !
While ſecond Cauſes *ſtudious we aſſign,*
Ne'er let us, mighty Lord, *forget the* Firſt !

Thee, Firſt *and* Laſt! *by whom all Things were made,*
For thy own Glory, and the gen'ral Good.——
What daring Man *ſhall impiouſly attempt*
To ſet at naught thy great important Laws?
Nothing in vain has thy great Hand deſign'd,
Replete with all that laviſh Hearts can wiſh.
Shall Atheiſts *ſay this glorious Fabrick roſe*
From Nature *only, not from* Nature's God?
O reign Supreme, *in Majeſty ador'd,*
Extend thy Sceptre o'er the Hearts of Men;
Cruſh Atheiſm *in its Birth, from Age to Age,*
While Thou *remain'ſt* One univerſal Cauſe,
The Father, *and the* Sov'reign *of the World.*

Reading, Nov. 26, 1758. MARCUS.

The

Plate I.

Fig. 1.

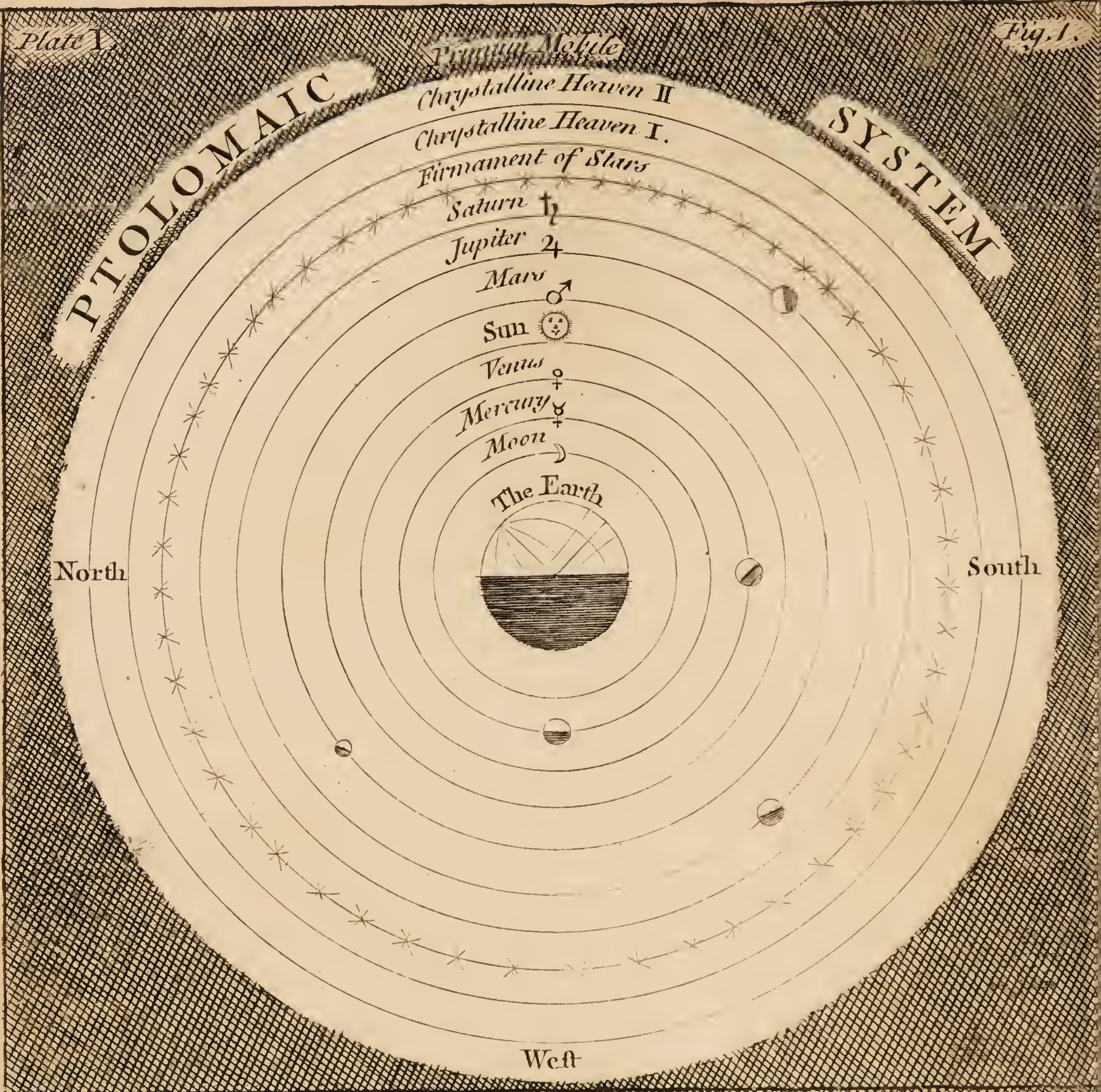
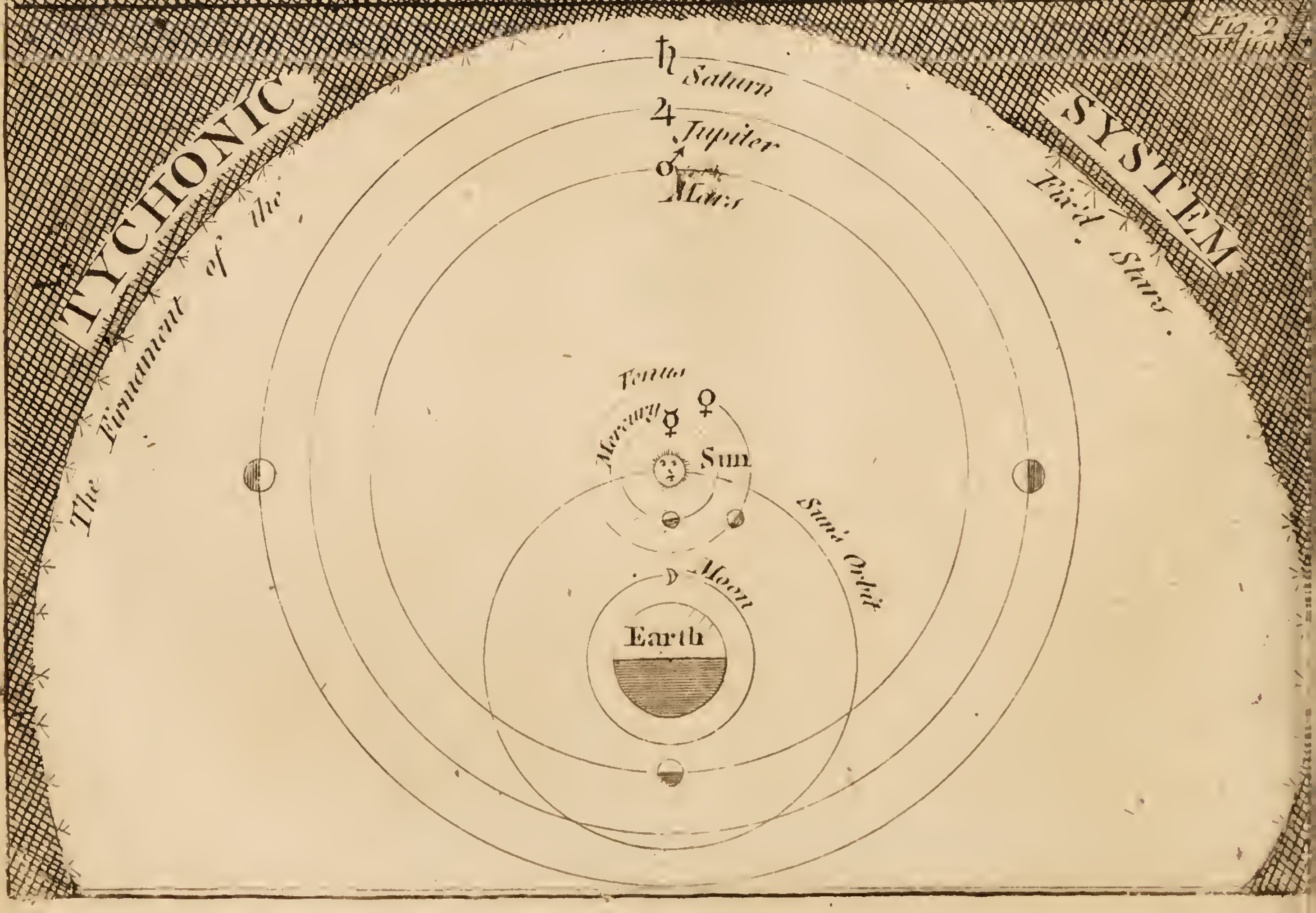


Fig. 2



The Young GENTLEMAN and LADY's PHILOSOPHY.

DIALOGUE I.

The Introduction.

Euphroſyne.

DEAR *Cleonicus*, I've been ſo affected with the pleaſing Diſcourſe you entertained us with laſt Night, that I know not which is greateſt, my Joy in ſeeing ſo near a Relation after ſo long Abſence at College, or the Happineſs I conceive will redound to me, and the Family, from the great Abilities and Improvements you've there acquired.

Cleonicus. Dear *Euphroſyne*, as I have been very induſtrious in improving my Time and Talents at College; ſo if any Satisfaction or Happineſs reſult from thence to any Perſon, and eſpecially to yourſelf, dear Siſter, I ſhall think myſelf highly compenſated. Your remarkable Diſpoſition to reading, I ſee, with the greateſt Pleaſure, has given you an elegant Taſte, and rendered you capable of Underſtanding, and converſing with Perſons on ſuch Subjects as come but too rarely on the Carpet in any Converſation, eſpecially that of your Sex.

Euphroſ. I ſuppoſe, Brother, you intend to make me a Compliment: Indeed I love reading very much, but wiſh I were more capable of improving by it. Philoſophy, I mean the Knowledge of natural Things in general, is what I ſhould be greatly pleaſed in the Study of, were it not ſo difficult a Science. I was charmed with the beautiful Sketches you gave the Company Yeſterday of ſome Parts of it.

Cleon. Philoſophy is the darling Science of every Man of Senſe, and is a peculiar Grace in the Fair Sex; and depend on it, Siſter, it is now growing into a Faſhion for the Ladies to ſtudy Philoſophy;

and I am very glad to ſee a Siſter of mine ſo well inclined to promote a Thing ſo laudable and honourable to her Sex.

Euphroſ. I often wiſh it did not look quite ſo maſculine for a Woman to talk of Philoſophy in Company; I have often ſat ſilent, and wanted Reſolution to aſk a Queſtion for fear of being thought aſſuming or impertinent. I ſhould be glad to ſee your Aſſertion verified; how happy will be the Age when the Ladies may modeſtly pretend to Knowledge, and appear learned without Singularity and Affectation! But can you give any Inſtances within your Knowledge of any Perſons of our Sex remarkable for this new Caſt of Thought?

Cleon. Yes, dear Siſter, ſeveral; in *London*, *Oxford*, and many other Places. I ſhall mention in Particular, *Euprepia*, a younger Daughter of *Eugenius*, to whom Nature has not been more indulgent in *Genius*, and fine Parts, than her Father has been careful in beſtowing on her a liberal and genteel Education, and ſhe herſelf ſedulous to improve both; ſo that ſhe is now not more conſpicuous for perſonal Charms and Beauty, than great and amiable for her ſingular good Senſe and Judgment, in natural Sciences eſpecially; on which Account ſhe is admired, eſteemed and beloved by all Gentlemen of Diſcernment. This fine Lady, you will eaſily judge, muſt be a notable Contraſt to *Thelia* Daughter of *Philargus*, who, being of a ſordid and contracted Temper, has beſtowed no more Education on his Daughter than Marking and making of Paſties; thus *Thelia* lives admired by yeomanly Boors.

Euphroſ. Indeed 'tis Pity there are ſo many young Ladies in *Thelia*'s Caſe; 'tis certainly more their Parents Fault than their own: *Thelia* might have been *Euprepia*, had *Eugenius* been *Thelia*'s Father. 'Tis our Part, *Cleonicus*, to bleſs God, that we had no *Philargus* to our Parent.

Cleon. 'Tis juſtly obſerved, *Euphroſyne*, and I often do: 'Tis our Happineſs that we have Parents whoſe Fortune enables, and whoſe Temper inclines, them to beſtow on us Education, and to train us up to truely honourable and polite Life. I have all the Advantages of the Univerſity, and you of the Boarding-School; while I purſue the ſeveral Studies of the *Latin*, *Greek* and Mathematical Literature, you apply to *French*, and the delightful Acquiſitions of the *Belles Lettres*.

Euphroſ. Dear *Cleonicus*, 'tis indeed my Happineſs to have divers Maſters and Tutors, as well as you; of one I learn *French*, of another to draw, a third teaches me Muſick, and a fourth Dancing: But among 'em all there is none well enough ſkill'd in Philoſophy to teach that in our School, were any of the young Ladies diſpoſed to learn; this I have learned by Enquiry of my Miſtreſs.

Cleon. As for *Maſters in Philoſophy*, 'tis a Thing as yet unheard of in private Schools; in the Univerſities there are indeed *Profeſſors of Philoſophy*, who ſometimes read Lectures on that Subject; but ſince I have the Pleaſure to find in you a Diſpoſition to Philoſophizing, I muſt tell you, that the only Way, at preſent, to learn Pholoſophy is from Books well wrote on that Subject. And then ——

Euphroſ. But, give me Leave to interrupt you a little, by aſking you a Queſtion; tho' indeed I am deſtitute of a Maſter, I am not of Books; my Father's Library, repleniſhed with the choiceſt Book on that Subject, is always, you know, at my Command: But then, this conſtant Difficulty occurs, that they are, for the moſt Part, unintelligible, by reaſon either of Schemes, or hard Terms, or abſtruſe Reaſonings, &c. Pray, how am I to be relieved or aſſiſted in ſuch a Caſe without a Maſter?

Cleon. Dear Siſter, 'tis the Fate of that Science to be attended with ſome Difficulties in the Study of it; theſe are no otherways to be removed than by the Aſſiſtance of learned Men and Books. But thoſe Parts of Philoſophy which are perplexed with Schemes and Abſtruſities, are generally ſuch as may be either wholly neglected as uſeleſs to the generality of People; or elſe may be explained in a more eaſy and familiar Manner by Experiments. Fear not, *Euphroſyne*, the greateſt and moſt delightful Part of this Science is within the Ladies Comprehenſion.

Euphroſ. You give me good Encouragement, Brother; I wiſh you may find the Succeſs of my Enquiries anſwerable; for I can aſſure you, I ſhall aſk you many impertinent Queſtions on this Subject before you return again to College.

Cleon. Not more, my dear *Euphroſyne*, than I ſhall be as glad to anſwer, if I can; but don't call 'em impertinent; or elſe know, that, in the Sciences, ſuch Impertinencies are the firſt Steps to Knowledge.

Euphroſ. Dear *Cleonicus*, you are very obliging; but ſuffer me to diſcover to you one Thing farther ———

Cleon. Yes, dear Siſter, I'm impatient to hear you.

Euphroſ. Be aſſured, then, that ſome Time before you came Home, while yet the happy Moments were near approaching, I had form'd, to myſelf, a Reſolution to purſue the Studies of Philoſophy, in ſomewhat of a Method, under your Inſtructions when preſent with us.——'Tis only to you, my *Cleonicus*, I may thus ſpeak without bluſhing.

Cleon. Modeſty, a moſt amiable Virtue in all, ſhould never be an Obſtacle to the forming, or proſecuting, any great, noble, or laudable Deſign; 'tis then a Fault only when Ambition is a Virtue. I am extremely pleaſed to underſtand your Purpoſe, and ſhall be glad to aſſiſt you all I can.

Euphroſ. Indeed I deſign to make a direct Buſineſs of it, while you are here; and therefore you may expect me to be as troubleſome as you pleaſe.———'Twill be beſt making Hay while the Sun ſhines.

Cleon. All Opportunities and Occaſions ſhall be employed to oblige a Siſter ſo dear to me as *Euphroſyne.* The Severities of Winter are now paſt; the Days are lengthening, the Sun renews his Warmth and Splendor, the Trees begin to bud, the Birds to ſing, and all Things now appear in the Serenity of a returning Spring; I therefore propoſe to ſpend thoſe vernal Evenings in familiar Diſcourſe on natural Things, while we walk round the Park, or over the Fields and Meadows, which make ſuch a delightful Landſcape all about us.

Euphroſ. If I miſtake not, this is ſomewhat like the Manner in which the Antients taught and learned Philoſophy, is it not?

Cleon. Yes; and you have read at the ſame Time, that *Ariſtotle* and his Diſciples were called *Peripatetics*, from their Cuſtom of teacing and diſputing as they *walked.*

Euphroſ. I have alſo read of that Sect called *Academiſts*, but have forgot on what Account they have that Name.

Cleon. You will eaſily recollect, that it was from a Place called *Academia*, a pleaſant Grove at *Athens*, in which *Plato*, and his Followers, taught Philoſophy.

Euphroſ. I have not read much on the antient Philoſophy, but I ſuppoſe that muſt needs come far ſhort of the Modern.

Cleon. Very far ſhort, indeed; the Difference is not much greater between Dreaming and Reaſoning; between the crepuſcular and the Noon-tide Light. The *Platonics* taught little more than ſome faint Notions of the *Deity*, which they called *Theology*; and the Doctrines of *Virtue* and *Manners*, which they called *Ethics*, or *Moral Philoſophy*. Soon after *Ariſtotle* enquired into the Cauſes and Nature of Things, but made no great Diſcoveries, as being deſtitute of the proper Means, *viz.* Inſtruments and Experiments; for which Reaſons that Science which is properly called *Phyſics*, or *Natural Philoſophy*, was brought to no Perfection 'till within theſe 200 Years, or, I may more juſtly ſay, 'till within theſe laſt 50 or 60 Years.

Euphroſ. Indeed I have often obſerved in the little Compaſs of my Reading that many great and uſeful Inventions have been aſcribed to ſeveral modern Names, as *Bacon*, *Boyle*, *Leibnitzs*, *Newton*, *Boerhaave*, *Halley*, *&c.* and have as often wondered how thoſe Things ſhould remain undiſcovered ſo long.

Cleon. The true Reaſon was, as I ſaid, for Want of a right Method of Philoſophizing, and proper Means to conduct them in their Purſuits; add to this, their Pride and Arrogance would not ſuffer them to appear ignorant of any Thing, and conſequently (not daring to appear in a Poſture of Enquiry) they knew little or nothing of the true Nature of Things. 'Twas my Lord *Bacon*'s great Soul which firſt pointed out the Way to real Knowledge, and the Hon. Mr. *Boyle* indefatigably purſued it in numberleſs Experiments, and diſcovered the true Nature of the Air. Sir *Iſaac Newton*, Dr. *Wallis*, *&c.* firſt improved the mechanical and mathematical Parts, and brought Aſtronomy to its greateſt Perfection. The learned Dr. *Herm. Boerhaave* made great Diſcoveries in Chemiſtry and the Nature of Plants and Minerals; and Mr. *Lewenhoeck*, that great Improver of the Microſcope, firſt brought to Light the inviſible Parts of Nature; the Theory of the Winds is now well nigh perfected by Dr. *Halley*, lately deceas'd. And laſtly all the valuable Curioſities and wond'rous Productions of Nature, are to be ſeen in the unparalleled Collection of the late Sir *Hans Sloane*, and in the Muſeum of the Royal Society.

Euphroſ. Since you mention the Royal Society, pray let me aſk you one Queſtion: 'What are thoſe called the *Tranſactions* of the Royal Society, I have never yet ſeen them, though I meet with perpetual References to them in every modern Piece of Philoſophy?

Cleon. They are a Sort of Regiſter and Journal of all the notable Experiments, Diſcoveries, Enterprizes, learned Diſcourſes, *&c.* which are conſtantly made by the Members of that Society at their ſeveral Meetings; and which are publiſhed in particular Numbers for the Promotion of Natural Knowledge, and the various Arts and Sciences among Mankind. Theſe Numbers are now very many, but are abridged by ſeveral Hands, for more general Uſe; and as they are the Treaſury of natural Science I deſign to make you a Preſent of them, to aſſiſt and encourage you in your intended Studies therein.

Euphroſ. Dear *Cleonicus*, your Kindneſſes to me are ſuch as I can never requite, but with the ſincereſt Love and Eſteem; they endear you to me in all the Characters of a Brother, a Friend, and a Tutor. But, as the Evening is now well ſpent, let us defer our farther Thoughts to the next convenient Seaſon.

Cleon. 'Tis true, my *Euphroſyne*, the Night, and Nature, calls us away to Reſt. The next Time we diſcourſe of theſe Matters, we will take a regular Method of contemplating Nature; ſurvey firſt the *Heavens*, then the *Air and its Meteors*; after that we will take a View of the Earth on which we live, and all its various Productions; and laſtly, we will recreate ourſelves with the delightful Diſcoveries of the Microſcope, and other curious Inſtruments by which Philoſopy has arrived at its preſent great Perfection. In the Courſe of theſe Meditations, we ſhall (in the Words of Sir *R. Blackmore)*

See thro' this vaſt extended Theatre,
Of Skill divine, what ſhining Marks appear!
Creating Pow'r is all around expreſt,
The God diſcover'd, and his Care confeſt;
Nature's high Birth her heav'nly Beauties ſhow,
By ev'ry Feature we the Parent know.
Th' expanded Spheres, amazing to the Sight,
Magnificent with Stars and Globes of Light;
The glorious Orbs which Heav'n's bright Hoſt compoſe,
The impriſon'd Sea, that reſiſtleſs ebbs and flows;

The fluctuating Fields of liquid Air,
With all the curious Meteors hov'ring there,
And the wide Regions of the Land proclaim,
The Pow'r divine that rais'd the mighty Frame.

Creation. *Pag.* 5.

DIALOGUE II.

Of the UNIVERSE, *and the ſeveral* SYSTEMS *of the* WORLD.

Cleonicus.

I Gueſs at your Wiſhes, Siſter; this fine Day terminates in a fair and delightful Evening, which invites us to the Pleaſures of a Walk; you are ready to go, but which Way are you inclined to take, the Park or the Fields, or along the winding Lanes?

Euphroſyne. The Park, this Evening, if you chuſe it, Brother.

Cleon. With all my Heart, *Euphroſyne*; come on, and while we take a Tour about the large extended Plain, aſk me any Queſtions your Curioſity may ſuggeſt, and I'll endeavour to anſwer them the beſt I can.

Euphroſ. I thank you, *Cleonicus*; I remember when we laſt diſcourſed together, you promiſed me a regular Account of natural Things, and ſaid we ſhould begin with the *Heavens*; this ſeems an ambiguous Term to me, pray, what do the Philoſophers mean by the *Heavens?*

Cleon. They ſometimes mean, the Sky or Firmament; ſometimes the Orbits of the Planets; ſometimes the Space of one Syſtem and ſometimes of all the Syſtems in the Univerſe.

Euphroſ. That I may have a yet clearer Idea of what you intend, I muſt beg you to explain the Terms *Univerſe*, *Syſtems*, *Space*, &c. for I would willingly underſtand Things aright.

Cleon. By the *Univerſe*, my *Euphroſyne*, you are to underſtand the whole Creation of all Things, together with the every Way infinitely extended Space or Void in which they have their Exiſtence.

Euphroſ. If, as you intimate, the Univerſe be infinite, how do you think it is furniſhed in the ſeveral Parts thereof, or is it all an empty Space beyond the Stars?

Cleon. The Philoſophers of the preſent Age teach us, that the Univerſe through all the boundleſs Space, is repleniſhed with Syſtems or Worlds of different Bodies. For by a *Syſtem*, they mean a Number of Bodies which move about one common Center or Point; and ſuch a Syſtem is what we call a *World*; and the moving Bodies of theſe Syſtems, we call *Planets* and *Comets* in ours.

Euphroſ. Do the Philoſophers know any thing of the ſeveral Syſtems or Worlds beſides our own?

Cleon. Not any Thing certainly; they only make probable Conjectures at moſt, and reaſon from the Analogy they obſerve between ſome Things in our Syſtem, and ſome in theirs, which they think alike; of which I ſhall be more particular when we talk of the Stars.

Euphroſ. You know beſt, dear *Cleonicus*, how to direct my Enquiries; I am content therefore if I can but obtain a general Knowledge of our own World; but what did you ſay, that all the Bodies of our World were moveable about a Center?

Cleon. Yes, all but one; and that one is it which poſſeſſeth the Center or middle Point of the Syſtem.

Euphroſ. Before I can aſk you a Queſtion I intend, you muſt, *Cleonicus*, tell me how many Bodies there are which compoſe our Syſtem or World?

Cleon. Thoſe whoſe Number is certain are, of the larger Sort, Six; *viz. Mercury*, *Venus*, the *Earth*, *Mars*, *Jupiter* and *Saturn*, beſides the *Sun* which is far greater than them all. But thoſe Bodies we call *Comets*, or *Blazing-ſtars*, are ſtill more, tho' uncertain in Number. Beſides all theſe, there are a leſſer Sort of Bodies in our Syſtem which move about the larger, and they are called *Satellites* or *Moons*, of which we can ſee but one with the naked Eye.

Euphroſ. But, dear *Cleonicus*, are not the Stars which twinkle all about us, and light us through gloomy Nights, a Part of our Syſtem?

Cleon. No; the Reaſon of which you will underſtand by-and-by.

Euphroſ. Then the Queſtion I would aſk, is; which of all thoſe Bodies you mention is That which remains at reſt in the Center of the Syſtem?

Cleon. That is the Queſtion, indeed; you will not a little wonder, perhaps, to hear, that the moſt learned Philoſophers have been controverſing this Point for above 2000 Years; Schools have diſputed with Schools; and many, and different Syſtems have been formed to ſolve the Appearances and Motions of the heavenly Bodies.

Euphroſ. I have read, I remember, of the Syſtems of *Ptolomy*, *Tycho*, and *Copernicus*; I ſuppoſe you mean theſe among the reſt, do you not, *Cleonicus*?

Cleon. Yes, my *Euphroſyne*, thoſe which you mention are the Principal; beſide which there were ſome others, as of *Kepler*, *Deſcartes*, *&c.* from ſuch a Variety of Notions, Sir *Richard Blackmore* ſays,

> *The old and new Aſtronomers in vain*
> *Attempt the heav'nly Motions to explain.*

But here Sir *Richard* was miſtaken; for the new Aſtronomers have very ſucceſsfully explained the heavenly Motions in every Reſpect.

Euphroſ. Tho' it may not be to much Purpoſe to have a large Account of all theſe Syſtems, yet I ſhould be glad juſt to know what they were, and how they differed from each other, in as few Words as you can.

Cleon. The Syſtem of the famous *Egyptian* Aſtronomer, *Ptolomy*, was the moſt groſs and vulgar: He ſuppoſed the Earth poſſeſſed the Center of the World, and that about it moved, firſt the Moon, then *Mercury*, then *Venus*; then the *Sun*; then *Mars*, *Jupiter* and *Saturn*; all in Orbs above each other; next above *Saturn* he placed the Firmament of the fixed Stars; and above theſe, two ſolid cryſtalline Spheres, one moving from Eaſt to Weſt, the other from North to South, and *vice verſâ.* All theſe he included in that Sphere he called the *Primum Mobile*, or firſt Mover, which, by a daily Motion about its Axis, carried the inferior Orbs from Eaſt to Weſt once in 24 Hours. But this Hypotheſis was far from ſolving the Appearances of the heavenly

Motions, and therefore is deſervedly thus cenſured by the aforeſaid Gentleman.

> *Firſt* Ptolomy *his Scheme celeſtial wrought,*
> *And of Machines a wild Proviſion brought.*
> *Orbs* centric *and* eccentric *he prepares,*
> Cycles *and* Epicycles, *ſolid Spheres,*
> *In order placed, and with bright Globes inlaid,*
> *To ſolve the Tours by heavenly Bodies made.*
> *But ſo perplex'd, ſo intricate a Frame;*
> *The later Ages with Deriſion name.*

This Syſtem you have repreſented in the Diagram I have drawn for you, (*Plate* I. *Fig.* 1.) and is evident by Inſpection only.

Euphroſ. It is ſo; it is the Figure of the Heavens, which I have ſeen in every common Map. But ſince *Tycho* diſapproved of *Ptolomy*'s Syſtem, I ſuppoſe he advanced one more plauſible; pray, what was peculiar to his?

Cleon. 'Tis ſaid, he placed the Earth in the Center of the Syſtem, and gave it only a diurnal Motion about its Axis once in 24 Hours; tho' ſome ſay, he made the *Earth* to be abſolutely at reſt. About the Earth he revolved the *Moon*, and alſo the *Sun*, but then about the Sun he placed the Orbs of *Mercury*, *Venus*, *Mars*, *Jupiter* and *Saturn*; ſo that they revolve at the ſame Time about the Earth once in a Year. Thus Sir *Richard:*

> *The famous* Dane, *who oft the* Moderns *guides,*
> *To Earth and Sun their Provinces divides;*
> *The Earth's Rotation makes the Night and Day;*
> *The Sun, revolving thro' the ecliptic Way,*
> *Effects the various Seaſons of the Year:*
> *Which, in their Turn, for happy Ends appear.*

This enormous Conſtruction of a Syſtem of the World I have repreſented alſo in a Scheme, for your more eaſy apprehending it. (*Fig.* 2.)

Euphroſ. I am obliged to you for it, as it is not quite ſo eaſy to get an Idea of it without. This Scheme of the Heavens, if I remember right, is alſo exploded; but I forget the particular Reaſons thereof.

Cleon. Becauſe in this, not only ſingle Planets, but a whole Syſtem is made to revolve about the Earth every Year; which is an Effect ſo prodigious to anſwer an End much eaſier brought about by a more ſimple and natural Contrivance, that it has been juſtly rejected by the *Moderns*, who all agree to admit the *Copernican* Syſtem as the only true and genuine one, of which we will hereafter diſcourſe more particularly.

DIALOGUE III.

Of the fallacious Reaſoning on which the PTOLOMAIC HYPOTHESIS *depends.*

Cleonicus.

WE laſt Night had a pleaſant Walk, in which I gave you a general Account of the *Ptolomaic* and *Tychonic* Syſtems; and as this Evening is like to prove very ſerene, if it be agreeable to you to take a Walk (after Tea) to the *Villa* beyond the *Park*, we will re-aſſume the Subject of the *Ptolomaic Syſtem*, and conſider a little more nicely the Merits of it.

Euphroſ. With all my Heart, *Cleonicus*; and I ſhould be glad to know the particular Reaſons why this Syſtem comes into ſuch Diſcredit among the Learned, when it ſeems, for the moſt part, agreeable to the Senſes, and is often mentioned in the Holy Scriptures.

Cleon. Neither of thoſe Arguments you now mention, my *Euphroſyne*, have any Weight with Gentlemen of Learning, nor yet with Ladies of good Senſe; and you'll find yourſelf able, with a little Reflection, to ſee they are not only abſurd, but even ridiculous; for you may as well think every Thing *true* you hear, as that every Thing is *juſt as* you ſee it.

Euphroſ. If we are not to believe our Senſes, *Cleonicus*, pray, why were they given us, and by what are we to be informed?

Cleon. Our Senſes are the general Means of Information, but they are all deceptive in ſome Meaſure; none more ſo than the Sight. My dear *Euphroſyne*, you will find it a dangerous Thing to truſt your *Eye-ſight* too far; our rational and diſcerning Faculties were given us for rectifying the Ideas of Senſes, and to diſcover Truth from Error. And herein conſiſts our Preeminence above Brutes. But to come nearer the Point. To ſuppoſe the *Earth at Reſt*, *only becauſe it appears to be ſo*, is the weakeſt Thing a Perſon can be capable of that pretends to any Reaſon at all.

Euphroſ. Why, *Cleonicus*, you ſeem very ſerious, and almoſt warm; if People are deceived by their Senſes, and impoſed upon by their Profeſſors, how can they help it?

Cleon. Very eaſily, my *Euphroſyne*, let them think and reaſon, and they will not be any longer the Dupes of Error and Impoſture. A common Sailor, who has little Reaſon enough in moſt of his Actions, would yet be aſhamed of ſuch an Abſurdity, as to conclude his Ship was at Reſt, becauſe it appears to be ſo to every one within it. And therefore, Siſter, when you are diſpoſed to take a Voyage to *France*, you will have an Opportunity of being convinced that Bodies in Motion will appear to be at Reſt, and Objects at Reſt appear to move, and ſo you will have no farther Difficulty in that Affair.

Euphroſ. Dear *Cleonicus*, I hope you will find ſome more agreeable Way to convince me, than by ſending me to Sea; for though I ſhould like to make the Tour of *France*, and to acquire philoſophical Experience in the Voyage; yet I cannot, by any Means, think of the terrible Element of the Ocean.

Cleon. Well, though it might anſwer a very good Purpoſe for you to ſee *Paris*, eſpecially as you might then convince the *Madames*, that the *Engliſh Ladies* excel them as much in Genius and Faculties of the Mind, as They do them in the Frippery of Dreſs, and perſonal Decorations: Yet, to ſave you all this Trouble, we need only take a Walk to yonder Hill, and our Purpoſe will be anſwered every whit as well.

Euphroſ. Indeed! *Cleonicus*; I ſhall gladly chuſe that Method rather than the other; but, pray, what curious Spectacle will there offer to confute ſuch a general Argument?

Cleon. Come with me, and you will ſoon ſee, my *Euphroſyne*: — You obſerve a Wind-mill is there placed on an elevated Ground, and that there is a Ladder by which you aſcend to the

Door.—Do you go up, and I will follow, when I have ſpoke a Word to one of the Millers.—Well, I ſee you are ſeated, and ſurveying the ſeveral Parts of the Machine; pray, how do you like being in a Wind-mill?

Euphroſ. Very well; I never was in one before; there is ſomething novel and ſtrange in the Structure, and I am greatly entertained with the Oddity of my Situation; but what amuſes me moſt of all is, the *Motion* of that large ſquare upright Poſt; ſee, how faſt it moves round!

Cleon. The Poſt move, Siſter; I ſee no Motion of a Poſt.

Euphroſ. Not ſee the Poſt move, *Cleonicus!* What has happened to you all at once, I hope you are not blind, can you ſee me?

Cleon. Yes, my *Euphroſyne*, with Pleaſure I ſee, and hear you too; but I ſee no Poſt move, really.

Euphroſ. Well, this is the moſt wonderful Thing I ever knew; for it has continued to move ever ſince I have been ſpeaking to you about it, and I never ſaw any Thing plainer in my Life than I ſee it move now. How is it, Brother, that you cannot ſee it likewiſe? I am amazed!

Cleon. You'll be further ſurprized, *Euphroſyne*, when I tell you, that though I ſee no Poſt move, I ſee the Mill itſelf move, and that I ſuppoſe is more than you can ſee; is it not ſo?

Euphroſ. Truely it is; the Mill move! I ſhould not have thought of it, *Cleonicus*. I ſit as perfectly at Reſt here as I do in the Parlour at home, and ſee no Motion in any Thing but the Poſt; or is it all Enchantment? But hold, I recollect what you ſaid by the Way; I believe I have diſcovered the Plot.

Cleon. I dare ſay you have; the End of your coming here is very well anſwered. You hereby ſee how very *fallacious the Sight is*; you ſaw the Poſt in Motion, and the Mill at Reſt, as you thought; but now look out at this little Window, *Euphroſyne*, and you'll ſee the whole Reaſon of ſuch a ſtrange Illuſion; obſerve *Rotato* the Miller, by means of that ſtrong Lever, turning the Mill round its Axle, or upright Poſt, which, when you go down, you'll ſee is fixed immoveably in the Earth; this they always do to ſet the Sails againſt the Wind. And this *real Motion* of the Body of the Mill cauſes that very curious, and indeed, wonderful apparent Motion of the *Swivel-poſt*.

Euphroſ. I am perfectly convinced by this Inſtance of the *Deception of Viſion*; I could never have thought it was poſſible in ſo great a Degree: I ſhall hence-forward have Reaſon to be more diffident, or leſs poſitive, with reſpect to common Notions and ſenſible Appearances.

Cleon. Very good, my *Euphroſyne*, it was for theſe Purpoſes I brought you hither. You will now readily grant the Earth may appear to be at Reſt, and yet really move, and that the *daily Motion* of the *Sun*, *Moon*, and *Stars* may not be *real* but *apparent*.

Euphroſ. I am fully ſatisfied upon that Head:—But what muſt I reply to thoſe who ſo religiouſly object the Scriptures mentioning the *Motion of the Sun*, and the *Earth at Reſt?*

Cleon. Very little will ſuffice for an intelligent Perſon, and there is no reaſoning with others.—As the Pen-men of the Scriptures never deſigned to give us a Syſtem of *Philoſophy*, or *Aſtronomy*, (which very probably they none of them underſtood rightly) ſo they every where accommodated their Diſcourſe and manner of ſpeaking to the common Underſtanding and Apprehenſions of the Vulgar. And indeed, it would be extremely abſurd to act otherwiſe. Sir *I. Newton* always ſaid the *Sun roſe and ſet*; and had he been in *Joſhua*'s Place would have ſaid as he did—*Sun*, *ſtand thou ſtill*, &c. Beſides, how weakly do we argue from the *literal Expreſſion of Scripture?* Does it not ſay, in one Place, *that the Earth is ſupported by Pillars?* And in another, that he (*viz.* God) has *hung the Earth upon nothing?* How contradictious are ſuch Expreſſions! And indeed, this Method of treating the Scriptures is not only injurious to the Sciences, but even to Religion itſelf.

Euphroſ. You have ſaid enough to ſatisfy me upon that Head, *Cleonicus*; and as it is far in the Evening, and we have a long Walk over the Park, let us ſet out; and when we come home, I ſhall be farther inquiſitive about this Matter.

Cleon. As much as you pleaſe, Siſter; I fear it will be too cold for you; put the beſt Foot foremoſt, and we ſhall ſoon be at home.

Euphroſ. I do not think of the Cold; my Head is employed about the Mill;—but, among all the bright Stars that light us home, how many Planets do you ſee, *Cleonicus?*

Cleon. There are no leſs than three which offer themſelves this Evening to the View, but one of them *(i. e. Mercury)* is now ſet; the bright *Evening-ſtar*, which you ſee low in the weſtern Hemiſphere, is the Planet *Venus*; and that pale-faced Planet which you ſee yonder, *South by Eaſt*, is *Saturn*; and all the reſt are *fixed Stars*.

Euphroſ. So the *Evening-ſtar*, that every body takes ſo much Notice of, is a *Planet*, I find; pray, *Cleonicus*, how am I to know a Planet from a Star at any Time?

Cleon. Very eaſily, Siſter, two ways; one is, that every fixed Star *twinkles*, but a Planet never does.

Euphroſ. Indeed; pray what can be the Reaſon of that, *Cleonicus?*

Cleon. The Stars are only *lucid Points* to Appearance, and therefore any opake Atom, or Particle, floating in the Air, is ſufficient to *eclipſe*, or cauſe a *momentary Occultation* of them; and this, joined with the Agitation or Tremours of the Air, will cauſe that conſtant Twinkling in the *Stars* which you ſee: But the Planets though ſmall, are ſtill bigger than thoſe Motes to the Eye, and therefore their Light will ſuffer little or no *Diminution*.

Euphroſ. Very good; and what is the ſecond Thing that diſtinguiſhes a Planet from a Star?

Cleon. This, my *Euphroſyne*, is the proper *Criterion* or Characteriſtic of a *Planet*, namely, a Planet is always in Motion from one Part of the Heavens to another, and from thence it is called a *Planet*, which in *Greek* ſignifies a *wandering Star*; now the other Stars are all fixed, and keep the ſame Diſtances conſtantly from each other.

Euphroſ. Dear *Cleonicus*, you have thoroughly prepared me to diſtinguiſh the Planets from the Stars.—I have one more Queſtion to aſk you, and that ſhall be all for To-night; what is the Sky or Firmament? And why does it appear always of that equally round Form?

Cleon. The Sky, my *Euphroſyne*, is not any Thing real, but only the *apparent Boundary of our Sight*; Space is every Way infinitely extended; but our Sight is terminated all around us, at a ſmall but equal Diſtance; and this is the only Reaſon why the Firmament appears of a perfectly ſpherical, concave Figure;

gure; for the Surface of a Sphere is every where equally diſtant from the Center, and every Man's Eye is the Center of his View; could he ſee farther one way than another, the Heavens would appear of an irregular Form, and quite different from that beautiful Hemiſphere, or azure Canopy, which conſtantly repreſents itſelf to our View.

Euphroſ. Well, *Cleonicus*, how happy would it be if every Walk I took for the future were to prove ſo delightful and inſtructive as this! But ſee,—the Candles are lighted, and Supper, I ſuppoſe, on the Table; we are at Home juſt in Time.

Cleon. We are ſo; but we will now ſolace ourſelves with the Refreſhments of kind Nature, and To-morrow re-aſſume this Subject; for many Things remain for my *Euphroſyne* yet to underſtand.

DIALOGUE IV.

A View of the demonſtrative Proofs of the FALSITY *of the* PTOLOMAIC HYPOTHESIS, *as repreſented in a* NEW PLANETARIUM.*

Euphroſyne.

THIS Morning, *Cleonicus*, I remember you told me we ſhould be employed in a more particular Conſideration of the *Ptolomaic Syſtem*; pray, in what Reſpect do you mean?

Cleon. I mean, my *Euphroſyne*, to point out to you thoſe particular *Phænomena* of the Heavens, which are eaſy to be obſerved by yourſelf, or any one, and which do of themſelves ſeverally evince the abſolute Falſity of the aforeſaid Syſtem; and you'll not be diſpleaſed to have it eaſily in your Power to refute an Hypotheſis in half an Hour, which has been univerſally and ſtrenuouſly maintained for Ages paſt.

Euphroſ.

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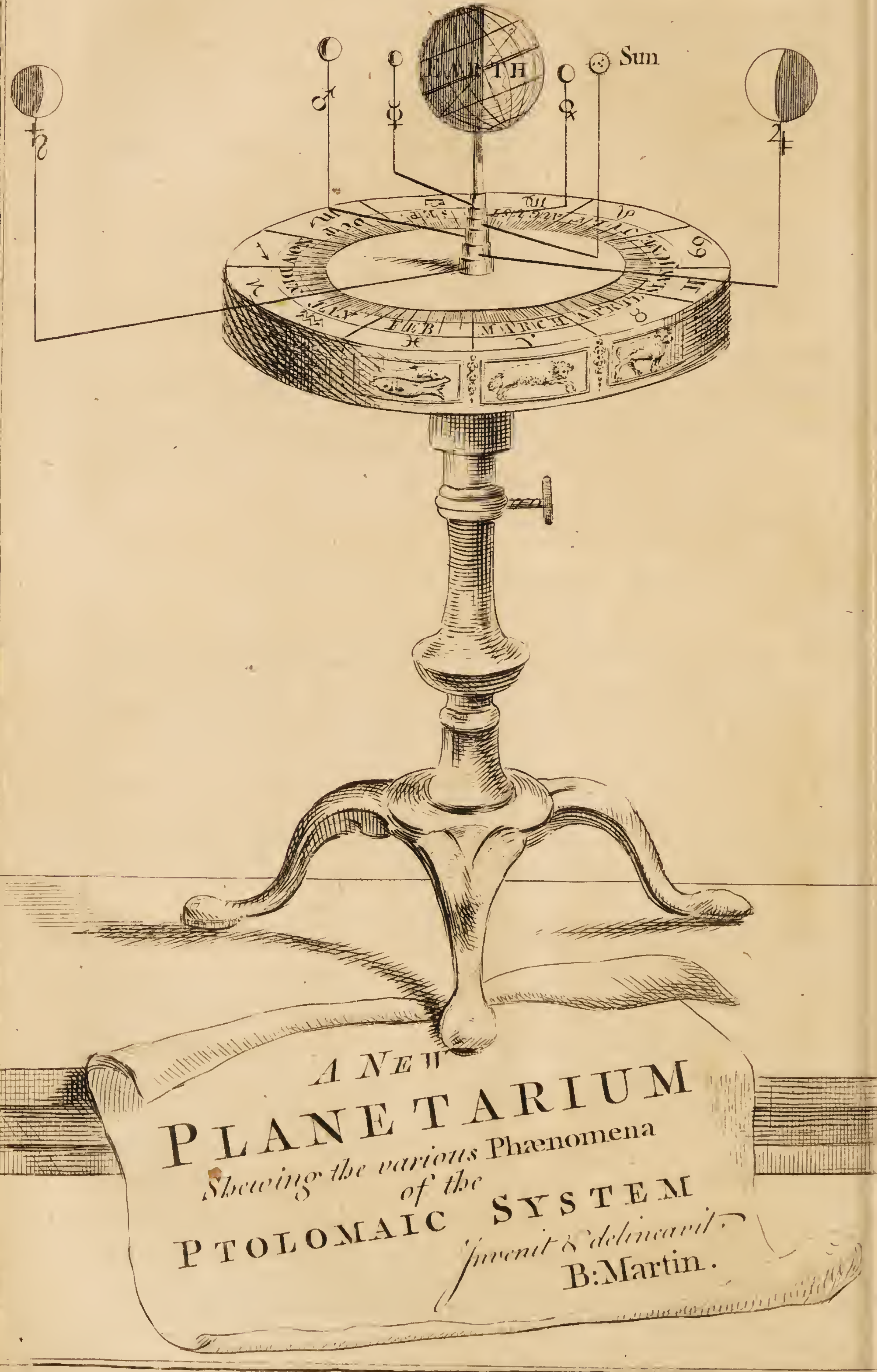
* The Reader, through this whole Dialogue, is to ſuppoſe, that the *Ptolomaic* Syſtem is repreſented by a new *Planetarium* with all the planetary Bodies, together with the Sun, revolving about the Earth at Reſt in the Center; which Machine is repreſented in a general Manner in *Plate* II.



A NEW
PLANETARIUM
Shewing the various Phænomena
of the
PTOLOMAIC SYSTEM
Invenit & delineavit.
B:Martin.

Euphroſ. Is this poſſible, *Cleonicus?*—This will be charming indeed. This will be doing great Things, ſure enough.

Cleon. You will ſoon be ſatisfied it is poſſible, by means of this Machine you ſee here, which is contrived for this very Purpoſe; for by it you will ſee both the *Ptolomaic* and *Copernican Syſtem* repreſented, and by comparing the Appearances in each of theſe with thoſe of the Heavens, you will obſerve ſuch a palpable Abſurdity and Repugnance in the one, and ſuch a perfect Conſiſtency and Agreement in the other, as will leave no Room for the leaſt Doubt, that one is *ſpurious and falſe*, and the other the *genuine and true Syſtem* of the *World*.

Euphroſ. Very good, my *Cleonicus*; but, pray, what do you call this curious Inſtrument, by the Way?

Cleon. It is called a PLANETARIUM; becauſe it exhibits a juſt View of the *planetary Syſtem*, at leaſt what relates to the Number, Order, and annual Motions of the primary Planets, all in the ſame Periods of Time as in the Heavens; for the *Wheel-work* is calculated to a *Minute of Time*.

Euphroſ. Very good, *Cleonicus*; I ſee the ſmall Globe of the Earth in the Center, and about it five round, Ivory Balls, which, I ſuppoſe, repreſent the *five Planets*; and a little *Braſs Ball* for the Sun, in the third Place from the Center; am I right, *Cleonicus?*

Cleon. You have a very juſt Notion of the Thing; you are perfectly right, Siſter. You farther obſerve, two Circles on the Surface of the Machine, one containing the 12 Signs of the Ecliptic, and the other the Calender of the Months and Days adapted to it, ſo that any Planet may be placed in that Part of the Ecliptic, or rather Zodiac, which it poſſeſſes for any Day of the Year, and ſo the whole Syſtem may be adjuſted for any given Time.

Euphroſ. Well; and ſo, by winding up the Machine, you put all the Planets, together with the Sun, in Motion about the central Earth, and thus you repreſent to me *Ptolomy*'s *Syſtem*.

Cleon. I do;—and now you ſee them all in Motion.—And the firſt Thing you ſee is an Argument which proves this Syſtem falſe, and that is,—that the two Planets next the Earth, *Mercury* and *Venus*, *can never be ſeen beyond the Sun in this Syſtem*.

Euphroſ. I plainly ſee it is impoſſible; becauſe their Orbits are both contained within the Orbit of the Sun. But are they ſeen at any Time to go beyond the Sun, *Cleonicus?*

Cleon. Yes, juſt as often as on this Side of it; as we ſhall have an Opportunity of obſerving ſoon.

Euphroſ. Such an Appearance will give me great Pleaſure, and be an undeniable Argument of the Falſity of this Syſtem.

Cleon. But you will find a ſecond Proof of the ſame Thing more flagrant, if poſſible, than the firſt.—For you ſee the Sun, there, in the *Weſt*, Siſter;—and if you look here, you will ſee the Planet *Mercury* in the *Eaſt*.—And, again, there you ſee the Planet *Venus* in the *South*.—Now theſe are ſuch Aſpects and Poſitions of the Planets as never were ſeen by any Man.

Euphroſ. If I take this Affair right, you mean to ſhew me, that if this were the true Syſtem, I might ſee (juſt after *Sun-ſet*, in a clear Evening) the Planets *Mercury* and *Venus* at any Diſtance from the Sun from *Weſt* to *Eaſt*, don't you, *Cleonicus?*

Cleon. That is the very Thing intended, my *Euphroſyne*; but you will eaſily recollect, that inſtead of ſeeing theſe Planets in every Part of the Heavens in a Star-light Evening, you ſeldom ſee them at all; nay, one of them, *Mercury*, ſo ſeldom, that you never yet obſerved it in the leaſt; and the other, *Venus*, or the *Evening-ſtar*, appears very rarely, being always near the Sun, and when fartheſt, not more than about 47°, that is, you never ſaw the ſaid Planet farther from the *Setting-ſun* than about *South-weſt*; you never ſaw it in the *South*, or *Eaſtern* Parts of the Hemiſphere of an Evening, which Phœnomenon does therefore inconteſtably prove the Abſurdity of this Syſtem.

Euphroſ. I am convinced of it thoroughly; I do not know that ever I ſaw the Planet *Mercury*; and as to *Venus*, I never ſaw her but in the Circumſtances you mention. But what is your next Argument againſt this *Hypotheſis?*

Cleon. The Earth being ſuppoſed the Center, the Planets will be in every Part of their Orbits at an *equal Diſtance*, and therefore will appear *equally big* at all Times; but this is contrary to all Appearances; for the *apparent Magnitude* of all the Planets is conſtantly variable: Nay, ſo great is the Difference in *Mars*, that at one Time he appears as large as *Jupiter*, and at another

Time ſo ſmall, that you cannot diſtinguiſh him from a *fixed Star*, but by his red Aſpect.

Euphroſ. If this be the Caſe, it muſt certainly be an indiſputable Argument againſt the *vulgar Hypotheſis*.

Cleon. You will hereafter be fully ſatisfied, by your own Experience, that is really the Caſe; at preſent, that Planet is not in a Situation to be obſerved, but he ſoon will.—I ſhall mention next another irrefragable Argument to the ſame Purpoſe.—You ſee the Planets in this Machine move with an uniform and equal Velocity in every Part of their Orbits.

Euphroſ. I do ſo; they move neither faſter nor ſlower in one Part than another.

Cleon. But this is not the Caſe of the Planets in the Heavens; for they all appear to move there with very unequal Paces; ſometimes they are *very ſlow* in Motion, ſometimes very quick, and ſometimes they appear *ſtationary* for ſome Time, or without any Motion at all. This you may be as eaſily convinced of as you can deſire, in a few Week's Time in the Planet *Venus*, which is now an Evening-ſtar, and very ſlow in moving from one fixed Star to another; but ſome Time hence, you will obſerve, ſhe has *no Motion* at all for ſeveral Days, then after that, you'll ſee her move very faſt back again towards the Sun, and be ſoon loſt in his Blaze. In all which Obſervations, I ſhall take particular Care to aſſiſt you.

Euphroſ. I ſhall be obliged to you, *Cleonicus*; and greatly pleaſed to obſerve ſuch curious Appearances of the Planets; eſpecially as they will afford me ſuch ample Conviction of the Falſity of this Syſtem, which ſhews this, and every Planet moving conſtantly with the ſame even Pace.

Cleon. There remains yet one more Obſervation to prove this Syſtem a moſt groſs and abſurd Hypotheſis, and that is—you obſerve, that a Spectator on the Earth, in the Center, would view all the Planets moving *one and the ſame Way continually*, or from *Weſt* to *Eaſt*; don't you, my *Euphroſyne?*

Euphroſ. Yes, I do very plainly; I am certain, from what I now ſee, that the Planets muſt neceſſarily appear to move as they really do, ſince we are ſuppoſed to be in the Center of their Motions.

Cleon. Very good, Siſter; but if we are not in the Center of their Motions, they cannot then be ſeen to move as they really do; but muſt of Courſe appear to move in a different Manner; and accordingly we always obſerve, that in the Heavens they appear to move ſometimes from *Weſt* to *Eaſt*, ſometimes from *Eaſt* to *Weſt*; and ſometimes to be *ſtationary*, and have no Motion at all.

Euphroſ. I make no Doubt of what you ſay; but you will readily ſuppoſe I am not *Aſtronomer* enough to have obſerved ſo much, *Cleonicus*.

Cleon. If you have not, you eaſily may, my *Euphroſyne*, at any Time almoſt; but at preſent you cannot wiſh for a better Opportunity; for the Planet *Venus* is now moving very ſlowly towards the Stars Eaſtward, therefore, the firſt Star-light Evening, obſerve her Diſtance from the next bright Star on the Eaſt, and you will ſee, in a few Days, that Diſtance will be diminiſhed by the Planet's Approach to the Star.

Euphroſ. Well, that I ſhall ſoon do, and by that Means know ſhe moves Eaſtwards. But what is the next Thing to be obſerved, *Cleonicus?*

Cleon. After you have ſome Time obſerved her Motion Eaſtward, you will find ſhe moves ſlower, by Degrees, till at laſt ſhe becomes *ſtationary*, or without any Motion at all; and this you will perceive by her keeping at the ſame Diſtance from a fixed Star for ſeveral Days together.

Euphroſ. Very good, *Cleonicus*, I ſhall endeavour to do that alſo; and what remains then?

Cleon. After that, Siſter, you will obſerve that ſplendid Planet return again towards the *Weſt*, and with a very quick Motion to meet the Sun, which ſhe will ſoon do; and thus you will obſerve, that ſoon after ſhe begins to be *retrograde*, ſhe is loſt in the ſolar Rays; or ſets *heliacally*, as we call it. Theſe Things you will find are all eaſy to be underſtood with a little Obſervation and Attention; and will be farther illuſtrated by Experiment, when I come to explain to you the beautiful Conſtruction of the *Copernican*, or true Syſtem of the World, in ſome of our future Speculations on theſe Subjects.

Euphroſ. Well, you can't imagine what Satisfaction and Pleaſure it gives me to underſtand how poor and unworthy an

Hypotheſis that of *Ptolomy* is; how very erroneous, groſs, and fallacious the Principles on which it depends; and how many, eaſy, and convincing Arguments we are ſupplied with, by Nature and common Senſe, to confute it.

Cleon. And, of Courſe, it muſt now appear wonderful to you, that there ſhould be ſo many Retainers to, and ſtrenuous Defenders of this abſurd Syſtem. But what can be ſaid of invincible Ignorance? It is to no Purpoſe to urge the Force of *Senſe* or *Reaſon*, nor even of *Truth* or *Demonſtration* againſt it. And therefore we muſt leave them to the Dominion of Error, and ſtudy only the Inſtruction of the happy few that are capable of Reaſon and Conviction.*

DIALOGUE V.

A Brief Account of the SOLAR SYSTEM.

Euphroſyne.

THE Morning having been advantageouſly ſpent in a Refutation of the *falſe Syſtem*; you are now, *Cleonicus*, indebted to me a few Hours this Afternoon, for an Explanation of the true Syſtem of the World, according to your Promiſe.

Cleon. My Promiſe ſhall be always ſacred, my *Euphroſyne*, and with the greateſt Pleaſure I ſhall now explain to you what is the true State of Nature, with regard to the *Mundane Syſtem* of planetary and cometary Worlds; which has been ſometimes called the *Pythagorean*, ſometimes the *Copernican*, now the *Newtonian*, and then the *Solar Syſtem*.

Euphroſ. Pray, why was it called the *Pythagorean* Syſtem, *Cleonicus?*

Cleon. Becauſe, anciently invented and taught by that famous *Grecian* Sage, *Pythagoras*, and continued ſo to be by his Followers;

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* The ſeveral Phœnomena of the *Ptolomaic* Syſtem, conſidered in this Dialogue, will evidently appear, if the Reader has his Eye upon the Diagram in the firſt Plate (*viz.* Fig. 1.) where the Earth, the Sun, and Planets are ſo placed, as to repreſent them ſeparately and diſtinctly to the View.

but being loſt, in the Ignorance and Barbarity of ſucceeding Ages, it was again retrieved, and maintained by *Copernicus*, about 200 Years ago; and for that Reaſon was called by his Name.

Euphroſ. And becauſe they placed the *Sun* in the Center, it was from thence called the *Solar Syſtem*, I ſuppoſe.

Cleon. You are right, Siſter; and the Appellation of *Newtonian* was given it from its being demonſtrated in every Part by that Prince of Philoſophers, Sir *Iſaac Newton*, who firſt diſcovered the Powers employed by Nature; and by obſerving the Phœnomena, explained and eſtabliſhed by that unerring Rule, all its Laws of Motion. Thus again Sir *Richard:*

> *The Maſters form'd in* Newton'*s famous School,*
> *Who does the Chief in modern Science rule,*
> *Erect their Schemes by mathematic Laws,*
> *And ſolve Appearances with juſt Applauſe.*

Euphroſ. Very *a-propos*, my *Cleonicus*; I find you are a *Newtonian* every Inch of you.

Cleon. Yes, and I expect to ſee you proſelyted to this, not more modiſh than true Philoſophy, before we leave the Subject. I can tell you, Sir *Iſaac* has no ſmall Party among the Principal of the *Fair Sex*.

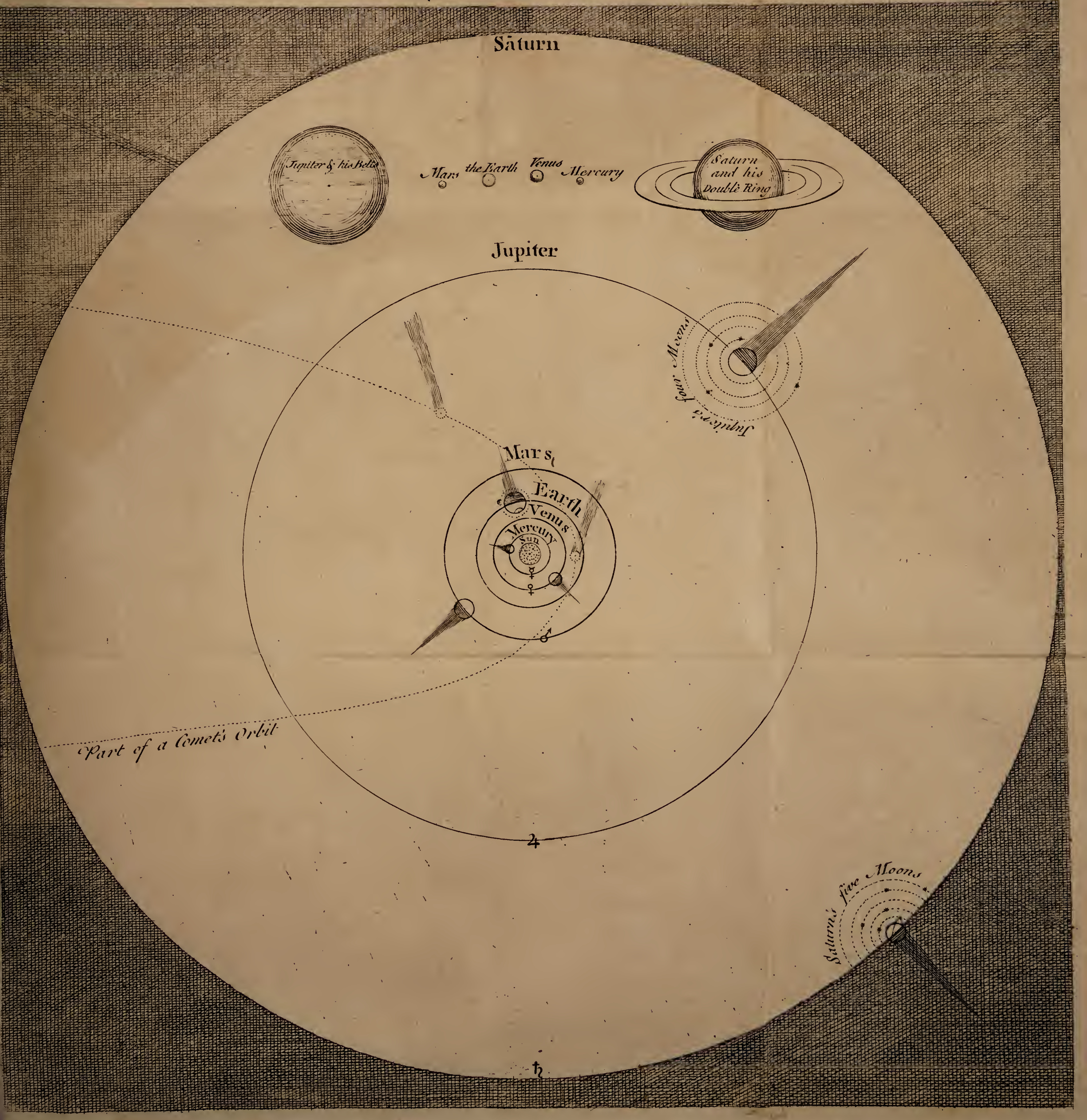
Euphroſ. I'm glad to hear it; I ſhall readily make one of the Number, if his Philoſophy be the beſt; but I beg leave firſt to underſtand it, if I can, *Cleonicus*.

Cleon. Your Requeſt is very rational; one Proſelyte of the Underſtanding is worth twenty of meer Faith in Philoſophy. I ſhall endeavour to give you a juſt Idea thereof, and its ſeveral Parts, by a Scheme which I have drawn up for that Purpoſe, and which is nearly a true Repreſentation of the *Solar Syſtem*, in which you ſee the Sun poſſeſſes nearly the central Point, for Reaſons we ſhall hereafter mention. By the *central Force*, or Power of Gravity, in the Sun, compounded with a projectile Force, there are found to revolve the *ſix Planets* following, *viz.* the firſt, or neareſt Planet to the Sun is *Mercury* ☿; the next is *Venus* ♀; the third is the *Earth*, with her *Moon*; the fourth is *Mars* ♂; the fifth *Jupiter* ♃; the ſixth and laſt is *Saturn* ♄; theſe all move about the central Sun in different Spaces or Periods

The COPERNICAN or SOLAR SYSTEM;

Shewing the Number, Order, Diſtances, *and* Magnitudes *of the* PRIMARY PLANETS *in proportion to that of the* SUN, *which is repreſented by the Sphere of* Saturn.

Plate III



riods of Time, and in Orbits that are very nearly circular, or ſuch as repreſented in this Scheme.

Euphroſ. I obſerve you have made the Orbs of the Planets circular, but the Orbit of a Comet, I ſee, you have repreſented as Part of a very long *Oval:* Do all the Comets go round the Sun in ſuch oval Figures?

Cleon. Yes, my *Euphroſyne*, they all move in Orbits, which are more or leſs oval, or (as the Aſtronomers call it) *Elliptical*; for what you call an *oval Figure*, they always call an *Ellipſis.*

Euphroſ. The Learned, 'tis fit, ſhould be allow'd to ſpeak in a Phraſe above what is vulgar; but I take it then only as uncivil or ungenteel Uſage, when they amuſe us with unintelligible Terms; ſince we ought always to underſtand what is offer'd us to read. But this by the Way; pray *Cleonicus*, what do you intend by thoſe ſmall Stars round *Jupiter* and *Saturn*, in the Scheme?

Cleon. They are little Moons, which the Aſtronomers call *Satellites*; theſe light thoſe diſtant Planets thro' their dreary Way; while others which are nearer the Sun, and have therefore a greater Degree of Light, have none of them, ſave our Earth only, which has but one.

Euphroſ. Theſe, I preſume, are all the great Bodies which compoſe our Syſtem, becauſe I ſee no more in the Scheme; but pray, what have you done with all the Stars? Do none of them fall to the Share of our World?

Cleon. They are all at a vaſt Diſtance from our Syſtem, and make no Part of it; as you will ſee hereafter. You will caſt your Eye on the Diagram once more, and obſerve, that the Bulks, or Magnitudes of the Sun and Planets are there alſo repreſented.

Euphroſ. I ſee it, I believe; does not the *Orb of Saturn* repreſent the Face of the Sun, and the ſeveral other white Globes the comparative Bigneſs of the Planets whoſe Names they bear?

Cleon. Yes, my *Euphroſyne*, they do; they are here drawn in Proportion to the Sun, of more than eight Inches in Diamater, and from thence you obſerve how ſmall a Figure even the largeſt of them all makes in Compariſon of that glorious, central, ſolar Globe.

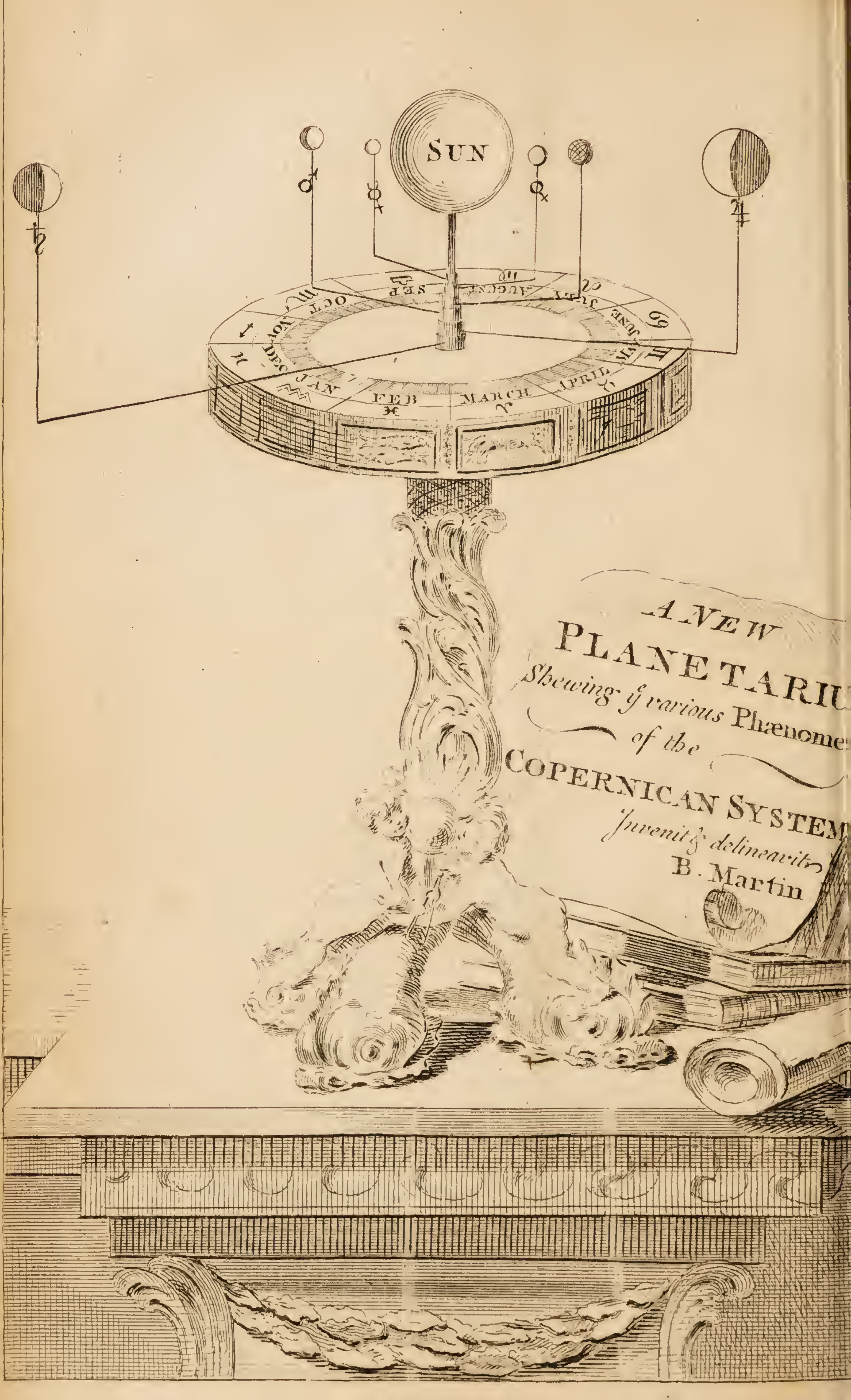
Euphroſ. Small indeed! I am almoſt aſhamed for our Earth; really 'tis ſcarce viſible in the Syſtem. Heavens! what a Buſtle do we Mortals, make about this Globe of Earth, when we ſee and conſider it alone; but how little a Thing does an Empire or Kingdom, nay, the Earth itſelf appear, compar'd with the whole Syſtem.

Cleon. What you obſerve, my *Euphroſyne*, is very juſt; we learn by ſuch Reflections one uſeful Leſſon, that Things are great and ſmall only by Compariſon; in regard to many other Properties of Bodies, you will find that this Doctrine will alſo hold good, as we proceed in our Speculations.

Euphroſ. I ſuppoſe, the Diſtances of the Planets repreſented in the Print, are in Proportion to thoſe in the Heavens, are they not, *Cleonicus?*

Cleon. They are ſo, as nearly as thoſe Diſtances are at preſent known; but in the Year 1761, when *Venus* will appear on the Sun's Face, the Diſtances of the Sun and Planets will be very accurately determined, and not till then. We ſhall therefore conclude with a View of this Syſtem in Sir *Richard*'s poetical Deſcription.

This wide Machine the Univerſe regard,
With how much Skill is each Apartment rear'd;
The SUN, *a Globe of Fire, a glowing Maſs,*
Hotter than melting Flint, or fluid Glaſs;
Of this our Syſtem holds the middle Place.
MERCURIUS *neareſt to the central Sun*
Does in an oval Orbit circling run;
But rarely is the Object of our Sight:
In ſolar Glory ſunk, and more prevailing Light.
VENUS *the next, whoſe lovely Beams adorn,*
As well the dewy Eve as opening Morn,
Does her fair Orb in beauteous Order run.
The GLOBE TERRESTRIAL *next, with ſlanting Poles;*
And all its pond'rous Load unwearied rolls.
Then we behold bright planetary JOVE,
Sublime in Air thro' his wide Province move.
Four Second Planets *his Dominion own,*
And round him turn as round the Earth the Moon.
SATURN *revolving in the higheſt Sphere*
With ling'ring Labour finiſhes his Year.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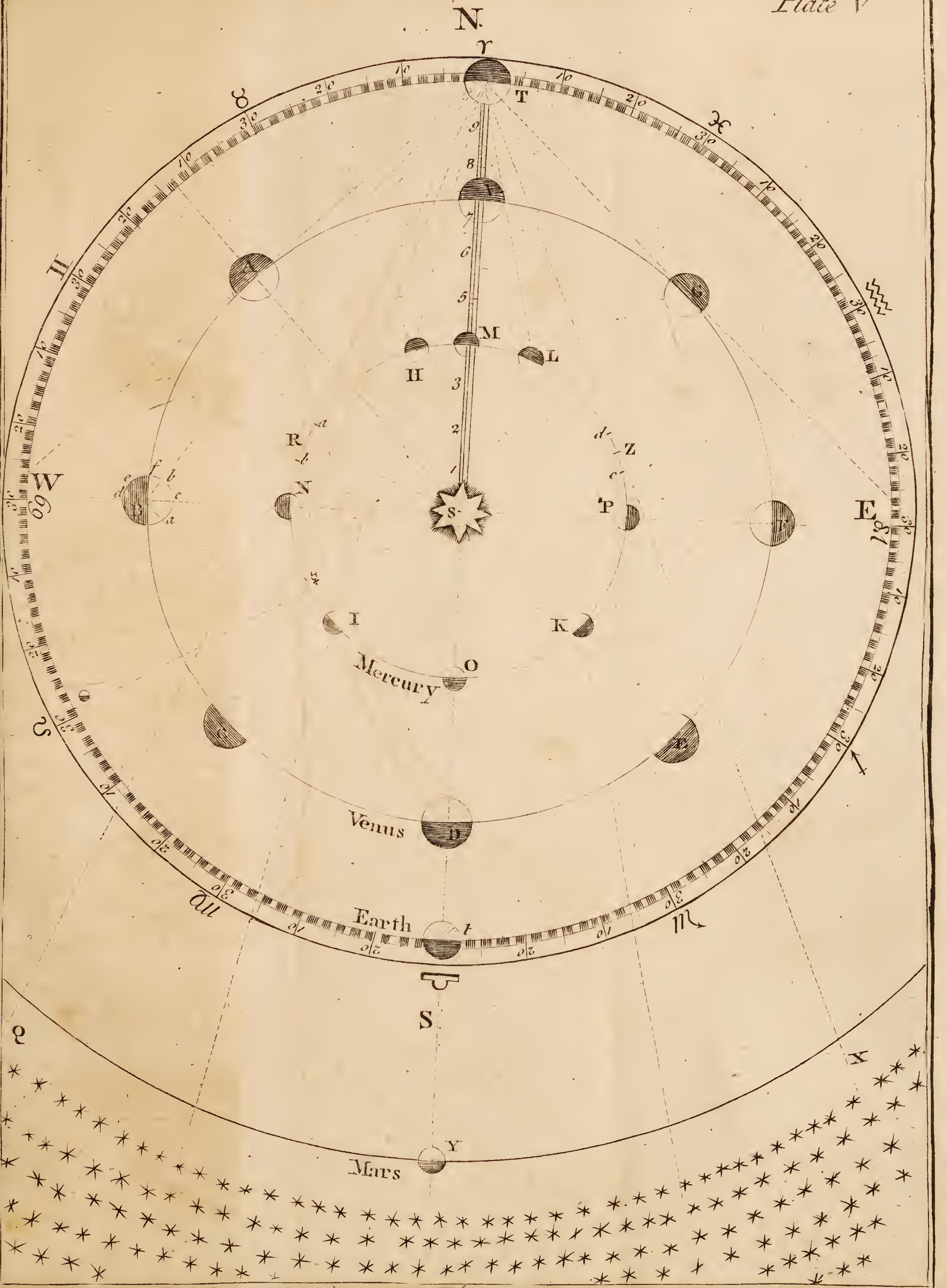
A NEW
PLANETARIU
Shewing y various Phænome
of the
COPERNICAN SYSTEM
Invenit & delineavit
B. Martin

Plate V



T. Bowen Sc.

DIALOGUE VI.

The Truth of the Solar Syſtem demonſtrated by the Planetarium.

Cleonicus.

BY this deſcriptive View of the Solar Syſtem, I preſume, my *Euphroſyne*, you will be prepared to underſtand a Demonſtration of the Truth of it, by comparing the ſeveral Appearances of the heavenly Bodies with thoſe of this Syſtem, as repreſented by the *Planetarium*.

Euphroſ. I make no Doubt, dear *Cleonicus*, but I ſhall, as you have a happy Method of repreſenting Things ſo natural and eaſy; eſpecially as I apprehend the Subject now is but juſt the Reverſe of what you ſhewed me before, when you refuted the *Ptolomaic Syſtem*, by the ſame Machine.

Cleon. It is true, my *Euphroſyne*, Truth is but the Reverſe of Error, at any Time, and to be convinced of the latter is more than half the Way towards a Diſcovery of the former. In order to this you obſerve, there is ſome Alteration made in the Face of the *Planetarium*.

Euphroſ. I do, *Cleonicus*, I ſee you have taken the Earth from the Center, and placed a large golden Ball in its Stead; alſo I obſerve, you have taken away the ſmall Braſs Ball from among the Planets (which before repreſented the Sun) and placed, in its Room, a little Ivory Ball, with Circles, to repreſent our Earth, I ſuppoſe, as no more than a *Planet*; theſe are bold Innovations, *Cleonicus*, in a Syſtem of Worlds; but I know you are able to anſwer for them, when there is Occaſion.

Cleon. Yes; while we are able to give a good Reaſon for what we do, we are always ſecure and courageous; 'tis a prodigious Advantage to have *Nature* and *Truth* both on our Side; one ſupplies us with all the Powers of *Logic* and *Rhetoric*, and the other renders us always victorious and triumphant. This has been, and ever will be the Caſe of the *Solar-Syſtem*, and all other Parts of the *Newtonian Philoſophy*, ſince they have been conſidered and treated in a proper Manner.

Euphroſ. Well, *Cleonicus*, I find you are a Champion in the Cauſe of Philoſophy; but put the Machine, if you pleaſe, into Motion, and let us proceed to Particulars; for I long to be inſtructed in this moſt beautiful Part of the Science.

Cleon. I will.——I wind up the Spring, and——you ſee all the Planets in Motion, at the different Diſtances, and Degrees of Velocity.

Euphroſ. I do, *Cleonicus*, with Abundance of Pleaſure; and I ſuppoſe, by this Means, I have now a proper Idea of the true Syſtem of the World; or is there any Thing yet wanting?

Cleon. Yes, my *Euphroſyne*, too much is yet wanting to compleat a perfect Idea of the Syſtem, at leaſt, in one View— Nor is it in the Power of Art to ſupply every Thing. The proportionable Diſtances of the Planets, together with the true Proportion of their Magnitudes, can never be ſhewn in any Machine, but ſeparately they may; as you have already obſerved in the Plate of the Solar Syſtem. And I ſhall only here obſerve, that if the Magnitudes are the ſame as there repreſented, the Diſtance of the Earth from the Sun would be 83 Feet, and that of *Saturn* nearly 800, ſo that the Orbit of *Saturn* would be almoſt a *Mile* in Circumference, and conſequently no *Planetarium* can ever be made to expreſs the Proportion of Diſtances and Magnitudes at the ſame Time.

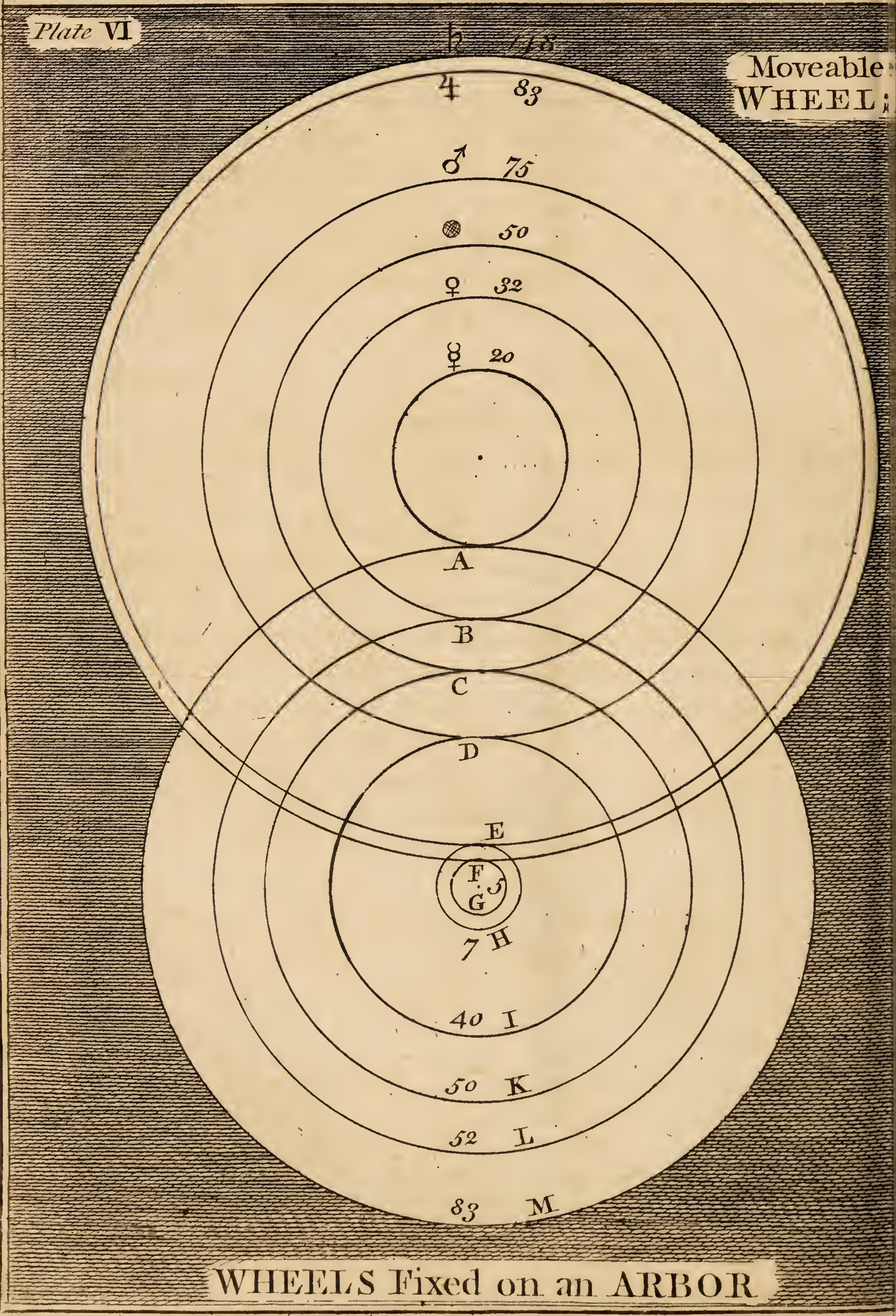
Euphroſ. I am convinced it cannot be done, *Cleonicus*, by what you have ſaid; and one Thing I obſerve farther, and that is, it would be but of little Uſe if it could be made ſo large; ſince then we muſt be at the Trouble of walking from one Part to another to view the ſeveral Bodies of the Syſtem; for it is eaſy to ſee, that *Mercury*, *Venus*, the *Earth*, and *Mars*, would be all of them by much too ſmall to be ſeen at the Diſtance of *Saturn*, (and indeed the three firſt at *Jupiter*) without a Teleſcope. I proteſt, *Cleonicus*, I can ſcarce reflect on ſuch diminutive Conſiderations of the Earth, without feeling ſome Uneaſineſs; I am quite concerned, when I think what a mean, and almoſt pitiful Figure we make in the Syſtem. However, there is one Comfort; we are not the leaſt of all the Planets.

Cleon.

A View of the WHEEL WORK *of th*

PLANETARIUM

Plate VI



Cleon. No, no, Siſter, don't be diſcouraged; our Earth is a Planet of the *third Magnitude*, if that will afford you any Conſolation. — But let us attend to the Machine; you there obſerve one Thing right, *viz.* the Velocity of the Motion of the Planets, and conſequently, the Planets here finiſh their Periods ſooner or later, juſt as they do in the Heavens. And not only this, but every other *Phænomenon* is the ſame here as you obſerve it in Nature, as will be evident by conſidering them ſeverally, as we did when the *Ptolomaic Syſtem* was repreſented, and confuted by it.

Euphroſ. This I ſhall attend to with great Pleaſure; for it is ſtill a ſuperior Satisfaction to ſee what Truth is, and the Ways and Means by which it is infallibly diſcovered; as our little mundane Syſtem, therefore, is all in Motion, pray, *Cleonicus*, proceed to Particulars.

Cleon. I will, my *Euphroſyne*, and begin with the *Phænomena* of *Mercury* and *Venus*, as before; only here you are ſuppoſed to be a Spectator of theſe Motions, from that ſmall Globe with Circles that repreſents the Earth; and from thence you ſee thoſe two Planets in one Part of their Orbits paſs before the Sun, and, in the other Part, behind, or beyond it; and this is their conſtant Appearance in the Heavens.*

Euphroſ. I ſee it muſt neceſſarily be ſo; and it is ſurprizing to me, that ſo very plain a Caſe was not alone ſufficient to convince Mankind in every Age of the Truth of this Syſtem.

Cleon. The longer you live, the leſs you will be ſurprized at ſuch Things; you will find Ignorance, Prejudice, Party or Policy, always eclipſing the Truth, as Clouds do the Sun, tho' both are in themſelves the brighteſt Objects in Nature. You will find, the next Phænomenon you obſerve is equally coercive, if Men would reflect or attend to it at all, *viz.* that *Mercury* and *Venus*, can never appear to us at any great Diſtance from the Sun; *Mercury* not above 21 Degrees, and *Venus* not more than

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* The Reader is here ſuppoſed to have his Eye upon the Diagram in Plate V. where all the Phænomena, mentioned in this Dialogue, are repreſented juſt as they are ſeen in the *Planetarium*. Thus, Phænomenon I. to an Eye placed on the Earth at T, the Planet *Mercury* at M, and *Venus* at V, will appear to paſs before the Sun; and at O and D they are beyond, or behind the Sun, if viewed from the ſame Place.

than 47; and this correſponds exactly with the Diſtances from the Sun in the Heavens when greateſt of all.†

Euphroſ. I have hardly Geometry enough to underſtand Meaſuring Diſtances by Degrees; but, I eaſily ſee the Thing you drive at, and indeed you have already explained it to me in a former Converſation.

Cleon. You will find, my *Euphroſyne*, that a very little Mathematics is requiſite for underſtanding the Phænomena, when we come to explain it ſtill farther by a proper Diagram, exhibiting the Theories of theſe two Planets; and a particular Piece of Machinery added to the Orrery for that Purpoſe: The next Phænomenon will create you no Difficulty; for as you obſerve, the Diſtance of the Earth is perpetually altering, with reſpect to any Planet, I ſuppoſe, you have Philoſophy enough to ſee what will follow from thence.*

Euphroſ. Very plainly, *Cleonicus*; I have, 'tis to be hoped, common Senſe enough to know, that when the Earth is near to any Planet,—that Planet will appear larger than it will do when the Earth is remote from it, and thence I may infer, that the apparent Magnitudes of the Planets are always variable; and ſo, I ſuppoſe, you obſerve them to be in the Heavens; for I remember well what you ſaid of the Planet *Mars*, when we conſidered this Phænomenon in *Ptolomy*'s Syſtem.

Cleon. I am glad to find you can ſo happily recollect, and compare theſe Appearances. We have, from the ſame Principle too, the Solution of another common Phænomenon of the Planets; pray do you remember that alſo?

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† Phænomenon II. If right Lines be drawn from the Earth at T, touching the Orbits of *Mercury* and *Venus*, in the Points R and A, on one Side, and Z and G on the other, 'tis evident thoſe Lines will be farther from the Sun, than Lines drawn to any other Points of thoſe Orbits, and conſequently, the Planets, in thoſe Points, will be ſeen farther from the Sun than in any other; and the Angle S T R will be found about 21 Degrees, and the Angle S T A about 47.

* Phænomenon III. 'Tis evident, that as the Planet *Mercury* moves from M to H N T; and *Venus* from V to A B C they will appear leſs and leſs; and that their apparent Magnitudes will encreaſe as they move from O to K P I, and from D to E F G towards the Earth at T, alſo ſince the Earth at T is about 5 Times farther from *Mars* at Y, than it is when at T, the ſaid Planet will appear 25 Times leſs in the Former than in the latter Situation.

Euphroſ. I believe I do; for my Reaſon ſuggeſts to me, that the apparent Motions of Bodies muſt be greater when they are near, than when they are very far off; and moreover, that their viſible Magnitudes and Motions are always greateſt and leaſt at the ſame Time *.

Cleon. Very good, my *Euphroſyne*; there is ſome Pleaſure in teaching Philoſophy to you, who will ſoon be Miſtreſs of many of the moſt uſeful Doctrines of the Science; you already know the Reaſon why the Planets apparent Motions muſt be very unequal; but why they ſhould ſometimes appear ſtationary, or without any Motion for a Time, I do not expect you to apprehend ſo readily as yet; but hereafter you will ſee no Difficulty in that.

Euphroſ. I perceive Science is a gradual Thing, *Cleonicus*; nor do I expect to be wiſe all at once: I ſhall be very well ſatisfied, if with Time, I can acquire ſuch a Competency of Knowledge as is fit for a *Woman*.

Cleon. You ſhould ſay, a *reaſonable Being*, my *Euphroſyne*; uſeful Science is of neither *Sex*, or any Party.——But to return.——While the Planets are in Motion, you obſerve, from the Earth they will be ſeen to move in *different Directions*; for Inſtance, *Mercury* you ſee is now on the *Left-Hand* ſide, or *Eaſt*, of the Sun; but from thence he moves on this Side of the Sun to the Weſt;——from that Weſtern Situation on the Right-Hand, he moves on behind the Sun to the Eaſt Side, where he was before; ſo that in one Revolution, he is ſeen to move from *Eaſt* to *Weſt*, and from *Weſt* to *Eaſt* †.

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* Phænomenon IV. In the Points of the Orbits where the Planets are neareſt, as at V and M, they will appear to move faſteſt; and *vice verſâ*, at the remoteſt Points O and D; alſo the Velocity of the Planet *Mars* at Y, will appear = 5 Times greater to the Earth at *t*, than it will do when the Earth is at T, at 5 Times the Diſtance as before.

† Phænomenon V. It is eaſy to obſerve in the Scheme, that to an Eye placed at T, the Planet *Mercury*, as it paſſes from R, by O, to Z, will appear to move forwards, according to the Order of the Signs, or from Weſt to Eaſt; but from Z, by M to R, it will appear to move the contrary Way, *viz.* from Eaſt to Weſt, or be retrograde. And a little Way on each Side the Points R and Z, *viz.* from A to B, and from C to D, the Planet muſt appear ſtationary, or at Reſt among

Euphroſ. I ſee it clearly, *Cleonicus*, and I remember alſo, you obſerved to me (in the other Syſtem) that this is the Caſe of all the Planets; and I expect I ſhall be able to ſee it verified by my own actual Obſervations on the Planet *Venus*, in a little Time, after the Manner you then directed me.

Cleon. You will then commence a *Practical Aſtronomer*, Siſter; and indeed by a little Attention and Practice, you will find it not only eaſy, but pleaſant to obſerve all the Phænomena of the Heavenly Bodies to be the very ſame as you have ſeen in this *Planetarium*; and then you will be fully convinced of the Truth of this Syſtem.

Euphroſ. I ſhall, nay, I am ſo already, *Cleonicus*; for I think it is impoſſible any one, who has ſeen all thoſe Things ſo naturally, and, as it were, doubly repreſented, as I have, ſhould not be convinced, at leaſt, that the Earth is a Planet, and the Third from the Sun;———But pray, *Cleonicus*, may not theſe Appearances happen to a Spectator on the Earth at Reſt among the Planets, as well as on the Suppoſition of its Motion; if ſo, there will ſtill lie an Objection againſt the Earth's Motion.

Cleon. 'Tis with great Pleaſure I hear you make this Queſtion, as you thereby diſcover almoſt a critical Sagacity in theſe Matters in ſo ſhort a Time. I anſwer, my *Euphroſyne*, the Phænomena, 'tis true, would be the ſame to the Earth at Reſt, as we have now ſpecified them; but you muſt know withal, that they would not, in that Caſe, happen at the ſame Times they now do, nor in the ſame Parts of the Heavens.

Euphroſ. I am very deſirous of ſeeing this illuſtrated, *Cleonicus*: Can you ſhew it in the *Planetarium?*

Cleon. Very eaſily; for I'll fix the Earth at Reſt in the Beginning of the Ecliptic, or firſt Point of *Aries* (as it is no Matter where) and bring the Planet *Mercury* in a right Line with the Earth and Sun; it is then in Conjunction with the Sun; then, putting the Machine in Motion, you obſerve that Planet, in 88 Days, comes to the ſame Place again, and therefore, if the Earth were at Reſt, the Time between two Conjunctions of the ſame Kind, would be juſt equal to the Period of the Planet's Revolution,

among the Stars at Q and X, ſince thoſe ſmall Parts of the Orbit do nearly coincide with the Tangent Line. But this Matter will be farther explained in a future Dialogue.

Revolution, and always in the ſame Point of the Ecliptic: Do you underſtand me? *

Euphroſ. I muſt be very dull indeed, if I did not perfectly well———

Cleon. Then ——— I put the Earth, as uſual, in Motion; ſetting out with the Planet; ——— but you ſee, when *Mercury* returns to the ſame Point again, the Earth is gone, and the Planet keeps moving on 'till it overtakes the Earth.—Here you obſerve a Time conſiderably longer than the Period is taken up between the two Conjunctions, *viz.* more than 110 Days.

Euphroſ. I ſee wonderfully plain, and alſo I obſerve the Earth has paſſed over about a third Part of its Orbit in the Time; and conſequently, I muſt needs know, that both the Time and Place of the preſent Conjunction are very different from the former; and therefore am neceſſarily convinced of the Motion of the Earth, as well as of all the reſt of the Planets about the Sun. I ſee the Truth, and much of the Beauty and Harmony of the Solar Syſtem; for which I ſhall be ever infinitely indebted to my dear *Cleonicus.*

Cleon. They who contemplate Nature, my *Euphroſyne*, always find their Admiration and Pleaſure encreaſing with their Knowledge; the more nearly we view her, the more engaging ſhe appears; and what you have yet ſeen is but, as it were, an *Antepaſt* of the ſublime Conſolations of Philoſophy, that will moſt certainly reward your future Enquiries, as you will acknowledge, when you come to underſtand the Doctrine of *Eclipſes*, and to be able to calculate one.

Euphroſ. To calculate an Eclipſe! A ſtrange Thing to talk of for a *Woman*, *Cleonicus.*

Cleon. A Woman! —— Why, this *Woman-hood* of yours, ſeems to be mightily in the Way. ——— I muſt tell you once more, my *Euphroſyne*, that it is at preſent quite out of the Queſtion; for if indulgent Heaven has favoured you with ſuch mental Faculties and Powers as will enable you to underſtand theſe Things, then why may you not with as good a Grace, and to as great an Advantage, addreſs yourſelf to ſuch an Undertaking? I know ſome Ladies, and doubt not but there are many others, who can calculate both a Solar and Lunar Eclipſe, and intend my *Euphroſyne* ſhall not be behind-hand with any of them. Nay, farther, I have a Sort of eaſy *Philoſophical Geometry* too, nicely adapted to the Genius of the *Fair Sex*, which will let you into the *Rationale*, or Reaſon of every Step you take in ſuch a Proceſs.

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* Phænomenon VI. In the Diagram, it is evident, if the Planet *Mercury* be in Conjunction at M, and the Earth at Reſt at T, it will be in Conjunction again, after one Revolution, in the ſame Point M, *viz.* in 88 Days. But ſuppoſing the Earth and Planet go on together from the Points T and M, the Planet will have made one Revolution, and Part of another, before it can get between the Earth and Sun; it will then be nearly in the Point ☿ and the Earth will be in ⊖, about four Signs diſtant from T, the Place of the former Conjunction.

Euphroſ. You have ſaid enough, *Cleonicus*; if you enlarge much farther, you will ſurely make an *Angel* of me.

Cleon. There is no Need of that, in the Judgment of ſome People that you know in the World.

Euphroſ. Prithee hold thy Tongue, *Cleonicus*;—and tell me what is in the Inſide of this Machine of yours: Is there any Thing that I can underſtand by what Means you make Art and Nature ſo wonderfully agree?

Cleon. Yes, ſurely, and nothing ſhall be denied to the Curioſity of my *Euphroſyne*; I will take off the Top of the Machine, — and there you obſerve ſeveral Parcels of Wheel-work, great, and ſmall. — Of the firſt, you ſee ſix Wheels all fixed on one Arbor.—

Euphroſ. I do, *Cleonicus*, and as they differ in Size, ſo I obſerve they do in Number of Teeth, which I ſuppoſe are ſhewn by the Figures ſtamped on each Wheel.

Cleon. You are right, Siſter, and you farther obſerve, the Teeth of theſe fixed Wheels play in the Teeth of ſix other moveable Wheels, all placed about one common Axle.—In each of theſe Wheels, there is fixed a long Pipe, or Socket, on the Top of which each Planet was fixed, as you ſaw on the Out-ſide of the Machine.—

Euphroſ. You need ſay no more, *Cleonicus*, for I obſerve now how the Planets are made to move in general; for when the Set of fixed Wheels are put into Motion, the other Wheels are ſeverally moved round in different Times, I ſee, by the different Number of Teeth in each.—

Cleon. Very well, my *Euphroſyne*, and in each Set you obſerve the *third Wheel* from the Bottom is the ſame, and has the ſame Number of Teeth, conſequently they go both once round in the ſame Time; therefore may repreſent our *Year*; for you ſee the Ball which repreſents our Earth is carried round on the Socket of that Wheel.

Euphroſ. All this I ſee very plainly; and how then, *Cleonicus?*

Cleon. Then by the Proportion of the other Wheels, the other Planets are made to revolve in their proper Periods of Time. Thus, the firſt Wheel of 83 Teeth drives the firſt of the other Set of 20; therefore *Mercury*, on its Socket, muſt move a little more than four Times round, while the Earth moves once round; for the Number of Teeth in the two Wheels will always be as the Number of Days in the Earth and Planets Revolutions, that is, 83 is to 20, as 365 to 88 nearly; and therefore in 88 Days, the Planet will make one Revolution about the Sun. I hope you underſtand me, Siſter?

Euphroſ. I do very well, *Cleonicus*; and for the ſame Reaſon, I ſee the Period of *Venus* is to the Length of our Year, as 32 to 52; in *Mars*, as 75 to 40; in *Jupiter*, as 83 to 7; and in *Saturn*, as 148 to 5. I ſee the Reaſon of this Affair with much more Eaſe than I imagined I ſhould.

Cleon. Every Thing, my *Euphroſyne*, will be tolerably eaſy, when it is well repreſented, and rightly conſidered; the Rationale of Things is not ſo very myſterious in ſuch Caſes, as is generally thought. —— In the Barrel, you ſee there is a Spring, which by Means of the Fuſee, and its Wheels, puts the Work into Motion; as in a common *Watch*, or *Spring-Clock*, and the Motion made equable by a Regulator: So much at preſent for the Mechaniſm of the *Planetarium*. We ſhall entertain ourſelves with a more immediate View of the great Bodies of the Syſtem, as we have Opportunity; and the next fair Evening, I will ſhew you the Face of the Sun thro' a *Teleſcope*, when he is near ſetting, for then we have the moſt advantageous View of that glorious Lamp of Day.*

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* The Reader will obſerve in Plate VI. that the

Moveable Wheel.		*Fixed Wheel.*
A ☿ of 20 Teeth	is driven by	A M of 83 Teeth.
B ♀ of 32		B I of 52
C ⊖ of 50		C K of 50

D ♂

Moveable Wheel.		*Fixed Wheel.*
D ♂ of 75 Teeth	is driven by	D I of 40 Teeth.
E ♃ of 83		E H of 7
F ♄ of 148		F G of 5

Hence, if the Time of one Revolution of the Wheel C ⊖, which carries the Earth, be divided into 365¼ equal Parts, or Days; therefore, ſince all the fixed Wheels make one Revolution in the ſame Time, it follows,

That 83 : 20 :: 365¼ : 87¾ = ☿'s Period.
52 : 32 :: 365¼ : 224⅔ = ♀'s Period.
40 : 75 :: 365¼ : 687 = ♂'s Period.
7 : 83 :: 365¼ : 4332½ = ♃'s Period.
5 : 148 :: 365¼ : 10759¼ = ♄'s Period.

From whence it appears how very accurately the *Annual Motions* of the Planets are determined by this Machinery.

DIALOGUE VII.

Of the SUN.

Cleonicus.

COME forth, my *Euphroſyne*, and let us walk to yonder little Hill, on the Summit of which, we ſhall have a delightful and inoffenſive Proſpect of the milder Sun in his Decline; and the Sky being ſerene, and free from Clouds, we ſhall ſee him gradually make his Exit out of our Hemiſphere to that below.

Euphroſ. That to me will be a grateful Sight, my *Cleonicus*; and I remember, in our laſt Converſation, you propoſed to contemplate the Nature of the Sun more immediately, when we ſhould next walk together.

Cleon. Yes, I did ſo; and, as if apprized of our Deſign, he ſeems to offer himſelf for the Subject of our Speculation this fair Evening. His Face looks of an inviting Aſpect, large, red, and gently glowing; which reminds me of the Poet's Deſcription:

The Diſk of Phœbus, *when he climbs on high,*
Appears at firſt but as a blood-ſhot Eye,
And when his Chariot downwards drives to Bed,
His Ball is with the ſame Suffuſion red;
But mounted high on his meridian Race,
All bright he ſhines, and with a better Face. Dryden's Ovid.

Euphroſ. Well, the Sun, to be ſure, is a noble Subject of Poetry, as well as Philoſophy! But, pray, *Cleonicus*, can you tell me any Thing of the Original of the Sun, and of what his wonderous Body is compoſed?

Cleon. Very little can be ſaid on that Head; *Moſes*, you know, informs us, that God, at the Creation, firſt called for *Light*, and then he made the *Sun*; and 'tis generally ſuppoſed, he made the huge Body of the Sun a Kind of Receptacle, or Reſervoir of Light, from whence it might be diſperſed thro' all Parts of the Syſtem; and thus the famous *Milton* has paraphraſed it in theſe excellent Lines:

Then of celeſtial Bodies firſt the Sun,
A mighty Sphere, he framed; unlightſome firſt,
Tho' of etherial Mould: He form'd the Moon
Globoſe, and every Magnitude of Stars.
Of Light by far the greater Part he took
Tranſplanted from her clouded Shrine, and plac'd
In the Sun's Orb, made porous to receive,
And drink the liquid Light; firm to retain
Her gather'd Beams: Great Palace now of Light;
Hither, as to their Fountain, other Stars
Repairing in their golden Urns draw Light;
And hence the Morning Planet gilds her Horns.

Paradiſe loſt.

Euphroſ. And does not the Light, thus collected, make the Sun's Body a Globe of Fire?

Cleon. Undoubtedly; and the moſt intenſe and ardent Heat poſſible muſt be there conceived.

Euphroſ. I imagine ſo; for I have ſeen a Book in my Papa's Library, which was wrote to prove, that the Sun was the horrible Place which we call *Hell.*

Cleon. 'Tis certain, the Sun is both large enough, and hot enough; and if it be not there, 'tis hard to ſay where it ſhould be. 'Tis certain, however, if *Milton* be right, the Devil is no Stranger in the Sun; for in his vagabond Flight thro' our Syſtem, he makes him light on the Sun, and compares him to a Spot in his Surface.

—— There lands the Fiend, a Spot like which perhaps
Aſtronomer in the Sun's lucid Orb,
Thro' his glaz'd optic Tube, yet never ſaw.

Euphroſ. This is a Fancy in the Poet pretty enough; and now you talk of Spots in the Sun, pray what, and how many are they? Have you ever ſeen them, *Cleonicus?*

Cleon. Yes, my *Euphroſyne*, very often; and they make a very odd Figure in the Sun's Face; their Number is very uncertain, being ſometimes more, ſometimes fewer, and ſometimes you will ſee none at all.

Euphroſ. How big do they appear?

Cleon. Some are large, and ſome ſmall; it has been obſerved, that ſome have been above 100dth Part as wide as the Sun's Face.

Euphroſ. How do they appear ſituated there?

Cleon. Sometimes many together in one Part, in another Part you ſee them ſingle; but they are hardly ever ſeen twice in the ſame Form, Magnitude, or Situation.

Euphroſ. Why then they are continually in Motion, I find; pray, is that Motion any Thing regular?

Cleon. Yes, extremely ſo at all Times; they move, all of them, from the *Eaſtern* to the *Weſtern* Limb of the Sun, and that in the Space of 13 Days nearly.

Euphroſ. When, and by whom were they firſt diſcovered?

Cleon. By the famous *Italian* Philoſopher *Galileo*, in the Year 1610.

Euphroſ. What do Philoſophers ſay they are?

Cleon. Why, I can aſſure you, dear Siſter, the *Indian* Kings, when here, were not more puzzled to account for the Nature, Appearance, and Diſappearance of the Beauty-ſpots on the Faces of the *Engliſh* Ladies, than the Aſtronomers are to account for thoſe of the Sun. Some think, they are not in the Body of the Sun, but are ſome dark Bodies, like Clouds, floating in an Atmoſphere about the Sun; and which, when before him, ſeem like Spots in his Surface. But others more probably ſuppoſe, they are really in the Sun, and occaſioned by an Eruption of Smoke, and other opacous Matter, in various Parts of his Surface; this, as it gradually ſpends itſelf, makes the Spots degenerate into others which look cloudy or miſty; and in the laſt

Place, the ſaid *Calx*, or dark Matter, being quite diſſipated, an Eruption of horrid * Flames ſucceeds, as in a *Volcano*, which make the bright and flaming Parts, that ſome have obſerved to come in Place of the Spots. This is the beſt Account, my *Euphroſyne*, that I can give of the *Solar Spots*.

Euphroſ. I thank you, Brother; but it would be a greater Gratification to have a Sight of theſe Spots; could you no how ſhew them to me?

Cleon. Yes, very eaſily; and 'tis what I intended, when we came out; for which Purpoſe, you ſee, I have brought with me this ſmall Teleſcope, in which I have put a ſmoaked Glaſs next the Eye, that the exceſſive Brightneſs of the Sun might not hurt it in viewing him.

Euphroſ. Dear Brother, I ſee you are very careful to oblige me in every Thing; but the Sun is almoſt down, if you be not ſpeedy, we ſhall loſe Sight of him.

Cleon. There is juſt Time enough; you will now ſee him alſo gradually deſcend the Horizon. Let the Tube be laid upon the upper Bar of this Gate, it will juſt fit your Eye.

Euphroſ. It does ſo indeed.———

Cleon. The Teleſcope is now right to the Sun; put your Eye to the End.

Euphroſ. I do.—

Cleon. Can you ſee any Thing?

Euphroſ. Yes, the Orb of the Sun, prodigious large and bright.—I ſee a Cluſter of Spots in the upper Part; I think there is about 11 or 12.—I ſee a very large one on the left Side,—and two more towards the Bottom.—'Tis an extreme Curioſity, indeed, but it makes my Eye ake.—

Cleon. Reſt a little, and then view him as he ſets.—

Euphroſ. I will.—But he ſeems now to touch the Earth.—I'll view him.

Cleon. He is not ſo near the Earth in the Glaſs.——

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* The *Feculæ*, or flaming Parts of the Sun, we have here mentioned, as they have been deſcribed by others, and particularly by Mr. *Derham*; but we muſt confeſs, tho' we have more than 30 Years conſtantly obſerved the Solar Diſk thro' very good Teleſcopes, we never ſaw the Appearance of any ſuch Thing.

Euphroſ. He's yet a Foot above the Earth: —— Now he juſt touches it; —— the two Spots below are juſt hid; —— the large Spot in the middle touches; —— is gone; —— the Cluſter begins to dip; —— they are all down; —— the Sun is almoſt gone; —— there, he is quite down. —— Well, of all things I ever yet ſaw, this is the moſt delightful and raviſhing Sight! How prodigious large he appears thro' the Glaſs! Pray, can you tell how big he really is?

Cleon. Not certainly; becauſe his Diſtance from the Earth is not certainly known; however, 'tis computed, that the Sun is in Diameter above *Eight Hundred Thouſand Miles*; and if ſo, his Bulk will be a *Million of Times* greater than our Earth.

Euphroſ. Prodigious! I do not wonder you place him in the Center of the Syſtem; it would be a monſtrous Piece of Contrivance, to make a Body ſo immenſely great as the Sun, move about the Earth, which in regard of him is ſo very ſmall.

Cleon. You conceive very well of the Matter, Siſter; ſuch Conduct, in forming a World, can never be ſuppoſed in the all-wiſe Creator, as would be unſufferable in a common Mechanic. But that the Sun is in the Center of our Syſtem you have already ſeen ſufficient Proof.

Euphroſ. And has the Sun, then, no Motion at all?

Cleon. If the Spots are only Blemiſhes in the Sun's Face, and are fixed there as Patches on a Lady's Face, 'tis certain, the Sun has a Motion about its own Center, or Axis; and that in about 25 Days 15 Hours. And this is now no longer an Uncertainty, but proved by the conſtant Uniformity of their Motion.

Euphroſ. But tho' the Sun may move upon it's Axis, yet I ſuppoſe it to be at Reſt in the Center of the Syſtem, I mean, ſo as not to move out of it's Place, is it not, *Cleonicus?*

Cleon. No, Siſter, not perfectly at Reſt there neither. For you muſt underſtand, there is a certain Point, which is the *true*, or *common Center* of all the Planetary Motions, and this Point is at moſt not quite a Diameter of the Sun diſtant from it's Center; about this Point, therefore, the Sun, as well as all the Planets, move; but in what Time is uncertain.

Euphroſ. Well, this Evening has been happily ſpent! And now upon our Return Home, let me know what Kind of poetical Philoſophers we have; for I make no doubt but the Muſes ſing very harmoniouſly on ſuch a glorious Subject.

Cleon. Oh, very finely indeed; the great Works and Scenes of Nature, you'll find, are the moſt agreeable Themes of the Muſes; they never ſing ſweeter than when they chant the Wiſdom and Magnificence of creating Power. Thus the Rev. Mr. *Brown:*

In the Beginning, the Almighty ſaid,
Let there be Light; *that Inſtant Darkneſs fled;*
All radiant Day her roſy Beams diſplay'd,
And the young World in ſplendid Dreſs array'd.
The blazing Sun, upriſing from the Eaſt,
Like a young Bridegroom in his Glories dreſs'd,
His ſpiral Courſe thro' Voids immenſe begun,
Ages to roll, and ſwift as Time to run,
Surveying, and ſurvey'd, throughout the Vaſt
Of the Creator's Works from firſt to laſt.
Or if, as more ſagacious Sages ſay,
He ſtands faſt fix'd amidſt a Flood of Day,
Around his Orb harmonious Planets race,
By his Attraction mov'd, thro' boundleſs Space.
——— *Hail ſacred Source of inexhauſted Light!*
Prodigious Inſtance of creating Might!
His Diſtance Man's Imagination foils;
His Numbers ſcarce avail to count the Miles.
His globous Body how immenſely great!
How fierce his Burnings! How intenſe his Heat!
As ſwift as Thought he darts his Radiance round,
To diſtant Worlds his Syſtem's utmoſt Bound.
Of all the Planets the directing Soul,
That hightens, and invigorates the Whole.

And Mr. *Baker*, in his *Univerſe:*

Along the Skies the Sun *obliquely rolls,*
Forſakes by Turns, and viſits both the Poles.
Diff'rent his Track, but conſtant his Career,
Divides the Times, and meaſures out the Year.

To Climes returns, where freezing Winter reigns,
Unbinds the Glebe, and fructifies the Plains.
The crackling Ice diſſolves; the Rivers flow:
Vines crown the Mountain-Tops, and Corn the Vales below.

Of his *genial Influences* and *Virtue* which he communicates to the Earth.

His Fires the gentle Flame of Life ſuſtain;
Hence Men and Beaſts and the innum'rous Train
Of Vegetables thrive; hence ſpring the Pow'rs
Which breathe *in* Animals, *and* bloom *in* Flow'rs.
Prize-Verſes, N°. IV. On Aſtronomy.

And *Cowley* thus:

The glorious Ruler of the Morning, ſo
But looks on Flowers, and ſtrait they grow;
And when his Beams their Light unfold,
Ripens the dull Earth, and warms it into Gold.

And of his Beams and Luſtre, which enlightens the whole Solar Syſtem, Mr. *Hulſe* thus poetically deſcants.

Around the Sun the Planets Orbs are hurl'd,
That Center, Eye, and Glory of the World.
See from his Orb, array'd in all it's Pride,
A ſpreading Luſtre ſtreams on ev'ry Side,
And in a Moment gilds the mighty Void!
His Orb ſo rich, his Beams ſo ſwift and bright,
Proclaim the God that made him infinite!

Euphroſ. As the glorious Orb of the Sun appears in all Ages the ſame, pray what did the Antients think of it, *Cleonicus?*

Cleon. Think, why they underſtood ſo little of Nature, exerciſed ſo little Reaſon, and were ſo very ſuperſtitious and devout, that, in ſhort, they made a GOD of him, and really worſhipped him as ſuch, under the Titles of *Phœbus*, *Apollo*, &c. as you will find at large in the *Pantheon.* And the Caſe is the ſame at this Day with the barbarous *Indians*, *Chineſe*, and other Nations abroad. Nay, our *Sabbath* is called *Sun-day*, as being the Day appropriated for the Worſhip of the SUN by our idolatrous Anceſtors, the *Saxons*.

Euphroſ. There's no Doubt but they worſhipped him as the *God* of *Day*, *Light*, and *Heat*; but what other Characters did he ſuſtain among them?

Cleon. They eſteemed him alſo the *God* of *Wiſdom* and *Harmony*; they painted *Apollo* with his *Harp*; and from the conſummate Beauty, Order, and Regularity which they obſerved in the Diſpoſition, and Motion of the heavenly Bodies, they aſſigned them all to his Dominion, and thence their Poets are often chanting the *Muſic* of the *Spheres*, as we ſhall hereafter ſee.

Euphroſ. Pray, *Cleonicus*, has the Sun any great Influence on the Weather, by which its Alterations can be foretold?

Cleon. Yes, Siſter, he has Influence enough on the Atmoſphere, and his Heat is the general Cauſe of all Meteors, and Variety of Weather; and, indeed, by viewing his Orb thro' the Body of Air, variouſly modified and altered by Vapours, they who are uſed to it, as *Huſband-men*, *Shepherds*, *&c.* may become ſo Weather-wiſe, as often to foretel the Changes that will happen in it. And ſo far the Precepts of *Virgil* are pertinent. *Thus*, of the *riſing Sun:*

————— The Sun, who never lies,
Foretels the Change of Weather in the Skies.
For if he riſe, unwilling, to his Race,
Clouds on his Brow, and Spots upon his Face;
Or, if thro' Miſts, he ſhoots his ſullen Beams,
Frugal of Light, in looſe and ſtraggling Streams,
Suſpect a driſling Day, with ſouthern Rain,
Fatal to Fruits, and Flocks, and promis'd Grain.
Or if Aurora, *with half-open'd Eyes,*
And a pale, ſickly Cheek, ſalute the Skies;
How ſhall the Vine, with tender Leaves, defend
Her teeming Cluſters, when the Storms deſcend?
When ridgy Roofs and Tiles can ſcarce avail
To bar the Ruin of the rattling Hail.

Then of the *ſetting Sun.*

But more than all, the ſetting Sun ſurvey,
When down the Steep of Heav'n he drives the Day.

For oft we find him finiſhing his Race,
With various Colours erring on his Face;
If firy red his glowing Globe deſcends,
High Winds, and furious Tempeſt he portends:
But, if his Cheeks are ſwoln with livid blue,
He bodes wet Weather by his wat'ry Hue,
And ſtreak'd with red, a troubled Colour ſhew;
That ſullen Mixture ſhall at once declare
Winds, Rain, and Storms, and elemental War:
What deſp'rate Mad-man then would venture o'er
The Frith, *or haul his Cables from the Shore?*
But, if with purple Rays he brings the Light,
And a pure Heav'n reſigns to quiet Night,
No riſing Winds, or falling Storms are nigh;
But northern Breezes through the Foreſt fly,
And drive the Rack, and purge the ruffled Sky.
Th' unerring Sun, by certain Signs, declares
What the late Ev'n, or early Morn prepares;
And when the South projects a ſtormy Day;
And when the clearing North will puff the Clouds away.
VIRG. GEOR. I.

Euphroſ. Well, this is very pretty, and, to be ſure, very poetical; and ſuch Obſervations on the Sun are undoubtedly of Uſe; but did not they go a Step farther, and ſuppoſe the Sun could alſo foretel future Events?

Cleon. Yes, my *Euphroſyne*, they did; and that to the utmoſt Superſtition of Aſtrology; and indeed, we find ſo great a Genius as *Virgil*, employing his Muſe on this vain and ludicrous Subject; for thus he proceeds, in the Place laſt mentioned.

The Sun reveals the Secrets of the Sky,
And who dares give the Source of Light the Lye?
The Change of Empires often he declares,
Fierce Tumults, hidden Treaſons, open Wars;
He firſt the Fate of Cæſar *did foretel,*
And pity'd Rome, *when* Rome *in* Cæſar *fell.*
In Iron Clouds conceal'd the public Light,
And impious Mortals fear'd eternal Night.

But it is no Wonder, if we find *Virgil* making Divination the Subject of Poetry; nor is it impoſſible for ſo wiſe a Man to be a little tainted with the prevailing Doctrine of that Age; and eſpecially, if we conſider, that his Father is reported to have been a Servant to one of thoſe *ſooth-ſaying Impoſtors.*

DIALOGUE VIII.

Of the PLANET *MERCURY.*

Cleonicus.

THIS Morning, my *Euphroſyne*, proves according to our Wiſhes; the Heavens are clear, eſpecially towards the auroral Eaſt, and will preſent us with a good Opportunity of viewing that rare Curioſity, the Planet *Mercury*. He is now at his greateſt Diſtance from the Sun, and riſes before him. He now anſwers to his poetical Character, of being the *Herald* of the *Gods*, and the *Meſſenger* of *Apollo*; for now, it ſeems, he does indeed precede his Sovereign, and proclaims to our diſtant Hemiſphere the gladſome Approach of Day.

Euphroſyne. Pray, *Cleonicus*, where is this extraordinary Planet? I never roſe ſo early, with ſo much Pleaſure, as I have done this Morning in Expectation of viewing him.

Cleon. My Chamber-Window commands a Proſpect of all the eaſtern Horizon; let us take a Teleſcope, and from thence view him before the too great Brightneſs of the riſing Sun obſcure him.

Euphroſ. Let us haſten thither;——your Window commands the Earth as well as Heavens; but, pray, to what Part muſt I look to ſee this rare Object?

Cleon. Let me ſee;——Oh, yonder he faintly appears, juſt over the Top of the Elm; you'll ſee him, if you direct your Eye to that Tree.

Euphroſ. I ſee him; pray, take the Teleſcope, and direct it to him.

Cleon. 'Tis done, my *Euphroſyne*; put your Eye to the End of the Tube, and view this *Harbinger* of *Day*.

Euphroſ. I ſee him; —— he appears very ſmall, but round, and ſomewhat globoſe; —— I ſee no Spot, or any Thing beſides a clear Circle of Light; —— he appears of a reddiſh Complexion in the Glaſs, tho' very pale without it; —— I have loſt Sight of him, by moving the Tube.

Cleon. You have ſeen all that can be ſeen in him; and you may ſay now, you have *once* ſeen *Mercury.*

Euphroſ. Dear *Cleonicus*, I am obliged to you for it. I think you ſaid, he was next to the Sun in the Syſtem.

Cleon. He is ſo; and yet he is computed to be no leſs than *Thirty-two Millions of Miles from the Sun.*

Euphroſ. Indeed! And, pray, can you tell me any Thing of the Magnitude of this Planet?

Cleon. Aſtronomers compute the Diameter of this Planet to be *Two Thouſand Four Hundred and Sixty Miles*; and, therefore, his Body will be a little above a 30th Part as big as our Earth.

Euphroſ. I think you obſerved to me, his Nearneſs to the Sun is the Reaſon why he is with ſo much Difficulty, and ſo ſeldom ſeen by us.

Cleon. I did ſo. He is the neareſt of all the Planets to the Sun; and his Orbit ſo ſmall, with Regard to the Diſtance of the Earth, that when he is in that Part of the Orbit wherein he appears fartheſt from the Sun, that will ſeem but a ſmall Space in the Heavens; and ſo muſt be taken juſt after Sun-ſet, or before Sun-riſing, according as he is Eaſt or Weſt of the Sun.

Euphroſ. I remember you told me, when you ſhewed me the Motion of the Planets in the *Planetarium*, that you could aſſiſt me yet farther by a Scheme, in underſtanding what relates to the Motions and Aſpects of the Planets; have you any ſuch Thing by you, *Cleonicus?*

Cleon. Yes; I have a Diagram of the Orbits of the *Earth*, *Venus*, and *Mercury*, with the Sun in the Center — Here it is.

Euphroſ. Very good; I ſee the Earth at T in the Outermoſt, and the Letters N, E, S, W, I ſuppoſe denotes the North, Eaſt, South and Weſt Points of its Orbit; am I right?

Cleon. Yes, my *Euphroſyne*; you will eaſily apprehend the Theory of the two inferior Planets, *Mercury* and *Venus*, from this Draught, I find.

Euphroſ. Cleonicus, don't flatter me.—In that inmoſt Circle or Orbit, the Globes I ſee at M, N, O, P, *&c.* I ſuppoſe repreſent *Mercury* in ſo many Points of his Orbit, do they not?

Cleon. Yes, they do; and firſt, when *Mercury* is in the Point M, he appears to the Earth, at T, to be in the ſame Part of the Heavens with the Sun, and ſo is ſaid to be conjoined with the Sun; from whence that Point is called the *inferior Conjunction* of the Planet.

Euphroſ. Since the Planet is then between the Earth and the Sun, does he not appear to go acroſs the Face of the Sun?

Cleon. Sometimes it ſo happens, but very ſeldom; becauſe *Mercury* does not move in the Plane of the Earth's Orbit. When he chances to traverſe the Sun's Face, he appears like a black Spot in the Sun; thus I ſaw him in the Years 1736, and 1743; and he may be ſeen again in the following Years, *viz.* 1756, 1769, 1776, 1782, 1789, in *October*. And in the Years 1753, 1786, 1799, in the Month of *April*, he will tranſit the Sun's Diſk, as the great Dr. *Halley* has certainly predicted.

Euphroſ. It ſeems to me from the Scheme, that this Planet muſt be again in Conjunction with the Sun in the Point O of its Orbit; for they are there both in the ſame Line from the Earth.

Cleon. 'Tis very true, and that is called the *ſuperior Conjunction* of *Mercury*. In that Situation he is never ſeen; for he either goes behind the Sun, and ſo is totally eclipſed; or if not, he is ſo near the Sun, and ſo ſmall, that he is wholly obſcured by the Sun's tranſcendent Light.

Euphroſ. Does not the Difference of his Diſtances in theſe two Conjunctions make a proportional Difference in his apparent Bulk? I think you told me ſo, *Cleonicus*.

Cleon. Yes, I did; for as he is above twice as far from the Earth in the Point O, as when he is in M, ſo he appears almoſt thrice as big in M, as he does in O, as they find, who have obſerved him in theſe Places with good Teleſcopes. The Poſitions of the Planet at N and P, are thoſe in the middle Points between the Conjunctions.

Euphroſ. But how comes it to have that particular Situation at R, in the Scheme?

Cleon. Becauſe that is the Part of the Orbit in which he appears to be at the greateſt Diſtance from the Sun, and which he poſſeſſes at this Time; for a ſtrait Line T R, drawn thro' the Centers of the Earth and Planet, does but juſt touch its Orbit. In this Caſe, he is ſaid to be in his *greateſt Elongation from the Sun.*

Euphroſ. I believe I apprehend you; for a Line joining the Centers of the Earth and Planet in any other Situation H I, would be nearer the Sun. But, which Way does the Planet move in its Orbit?

Cleon. I thought your Memory would have let nothing ſlip; but you will eaſily recollect, that it moves from M to R, and ſo by N to O and P. That is, it moves from the *North* to the *Weſt*, to the *South* and *Eaſt*, if I may be allowed ſo to expreſs it.

Euphroſ. Then I ſee, while *Mercury* paſſes through the Right-hand Half of its Orbit from M by N to O, he will be ſeen on the Weſt Side of the Sun; and while he marches through the other Half O P M, he will appear Eaſtward of the Sun.

Cleon. Very right, my *Euphroſyne*; he will ſo; and therefore from the Time of his inferior to his ſuperior Conjuction, he will *riſe and ſet before the Sun*; but from his ſuperior Conjunction to his inferior, he will *riſe and ſet after the Sun*; in which Caſe, he will be viſible only in the Evening; in the other, (which is the preſent Caſe) he can be ſeen only in the Morning.

Euphroſ. This is all very plain; and I remember you told me in a general Way, that he made his Tour about the Sun in 88 Days; but, pray, what is the preciſe Time of Period?

Cleon. *Mercury* revolves about the Sun in the Space of 87 Days, 23 Hours, and 16 Minutes, wherefore the Year to the *Mercurians* is about one Quarter of our Year.

Euphroſ. Now you talk of the Inhabitants of *Mercury*, pray, if there be any, how is it poſſible they ſhould endure the exceſſive Heat of the Sun there, being ſo near to him?

Cleon. The Heat there muſt be about ſeven Times as hot as our Torrid Zone; but the Bodies of Animals and Vegetables, if any, muſt be tempered accordingly to ſuſtain it. It is an equal Taſk to Omnipotence to make a Claſs of Beings as fit to endure one Degree of Heat or Cold, as another. Mr. *Baker* has ſome fine Lines on this Head.

Firſt MERCURY, *amidſt full Tides of Light,*
Rolls next the SUN, *thro' his ſmall Circle bright.*
All that dwell there muſt be refin'd and pure ;
Bodies, like ours, ſuch Ardour can't endure.
Our EARTH *would blaze beneath ſo fierce a Ray,*
And all its Marble Mountains melt away. Univerſe.

Alſo, thus Mr. *Brown* in his Prize-Verſes on Aſtronomy:

In the near Neighbourhood of Phœbus' *Car*
Rolls, ſwiftly circl'ing, the Mercurial *Star ;*
Obſcure he moves, immers'd in Floods of Light,
And ſeldom greets the nice Obſerver's Sight :
Then moſt conſpicuous, when th' eclipſing Moon,
With interpoſing Shadow, veils the Sun. N°. IV.

And again in N°. III.

Firſt verging on the lucid Fount of Day,
Bright MERCURY *directs his circling Way ;*
In three ſhort Months he rounds the ſolar Sphere ;
His Seaſons ſhift, and ends his tranſient Year.

Euphroſ. I ſuppoſe it was from this quick Motion of his, that he obtained the Poſt held among the Gods ; at leaſt, I learn this Hint from the *Pantheon*, in which I have been pretty converſant ſince you referred me to it in our laſt Conference about the Sun.

Cleon. Yes, he was, from the Velocity of his Motion, conſidered Mythologically, as the *Meſſenger* of the *Gods*, by the Poets of thoſe fabulous Ages ; his Office was denoted by emblematical Wings on his Head and Feet, and his *Caduceus*, or Rod of Authority, entwined by two winged Serpents, which he carried in his Hand ; and thus he is deſcribed by *Virgil*, when ſent by *Jupiter* to prepare a kind Reception for *Æneas* among the *Carthaginians.*

Down from the Steep of Heav'n Cyllenius *flies,*
And cleaves with all his Wings the yielding Skies :
Soon on the Lybian *Shore deſcends the God ;*
Performs his Meſſage, and diſplays his Rod. ÆNEID I.

Some Time after, he receives a Commiſſion from *Jupiter*, to order *Æneas* to retreat from *Carthage*, in the following Lines:

He calls Cyllenius, *and the God attends;*
By whom his menacing Command he ſends.
Go, mount the weſtern Winds, and cleave the Sky,
Then, with a ſwift Deſcent, to Carthage *fly;*
There find the Trojan *Chief.* ———

His Inſtruction given,

Hermes *obeys; with golden Pinions binds*
His flying Feet, and mounts the weſtern Winds:
And whether o'er the Seas, or Earth he flies,
With rapid Force, they bear him down the Skies.
But firſt, he graſps within his awful Hand,
The Mark of Sov'reign Power, his Magic Wand:
With this, he draws the Ghoſts from hollow Graves,
With this, he drives them down the Stygian *Waves;*
With this, he ſeals in Sleep, the wakeful Sight;
And Eyes, tho' clos'd in Death, reſtores to Light.

ÆNEID IV.

DIALOGUE IX.

Of the PLANET *VENUS.*

Euphroſyne.

DEAR *Cleonicus*, this Morning you entertained me with an Account of the Planet *Mercury*; and, if you think fit, we will ſpend this Evening in diſcourſing of *Venus*, which you ſaid was next to *Mercury*, in the Syſtem.

Cleon. Nothing will be more agreeable to me, *Euphroſyne*; and it happens very opportunely for us, that *Venus* is now alſo in her greateſt Elongation, or fartheſt Diſtance from the Sun, and therefore will, in this clear Evening, afford us a moſt ſplendid Appearance. It is but ſtepping Without-doors, and looking Weſtward, you'll ſee her Ladyſhip very brillant.

Euphroſ. I believe I do; for I preſume it is that large, bright Star, that appears alone in the Heavens over yonder Hill.

Cleon. Yes, that is ſhe; let us take a Walk to the Hill, and there view her with the Teleſcope on the ſame Gate we viewed the Sun.

Euphroſ. With all my Heart, dear *Cleonicus*; come away; I long to ſee her Face in the Optic-Glaſs.

Cleon. As we go over theſe three or four pleaſant Fields, let us view her Orbit in the little Scheme we uſed in the Morning. ——— Here it is. *

Euphroſ. Very good; I ſee *Venus*'s Orbit; — it is that which lies between *Mercury* and the *Earth*.

Cleon. It is ſo; and for that Reaſon, ſhe has the ſame Appearances, with Reſpect to the Earth, as *Mercury* had, *viz.* ſhe has an *inferior Conjunction* at V, and a *ſuperior One* at D; and while ſhe paſſeth from V by B to D, ſhe is ſeen at the Earth T on the *Weſt Side* of the Sun; and while ſhe goes from D by F to V, ſhe appears on the *Eaſt Side* of the Sun.

Euphroſ. Then alſo, when ſhe is Weſt of the Sun, ſhe riſes and ſets before him; and when Eaſt, ſhe ſets and riſes after him, as you ſaid of *Mercury*; I preſume I am right, *Cleonicus.*

Cleon. Very right, Siſter; and for that Reaſon, ſhe appears, in the firſt Caſe, only in the *Mornings*, and in the latter, only in the *Evenings*; on which Account (becauſe ſhe is bright and appears firſt) ſhe is called the *Morning* and the *Evening Star*, by Way of Preheminence. Accordingly Mr. *Baker* thus deſcribes her:

Fair VENUS *next fulfils her larger Round,*
With ſofter Beams, and milder Glory crown'd;
Friend to Mankind, ſhe glitters from afar,
Now the bright Ev'ning, *now the* Morning Star.

UNIVERSE.

Euphroſ. On the ſame Account, I ſuppoſe, it was, that ſhe had the Name of *Phoſphor* and *Veſper*, among the heathen Poets; for you muſt know, I am now ſo well read in the *Pantheon*, that

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* The Reader is referred to Plate V. Page 25, for every Thing that relates to the Theories of *Mercury* and *Venus* in the laſt, and preſent Dialogue.

that I can quote Chapter and Verſe for almoſt any Thing you find in the Heavens.

Cleon. Thus it was, indeed; for when ſhe was the *Morning Star*, the *Greeks* called her *Phoſphor*, and the *Latins* called her *Lucifer*, both which Names import ſhe uſhered in the *Light*, and *Day*; and when ſhe was the *Evening Star* ſhe was called *Veſper*, and *Heſperus*, by the *Greeks*; which Names alſo ſignify the *Evening*, or *Cloſe of Day*, among thoſe People. Thus Mr. *Brown.*

> *But ſee! how gentle* Veſper, *ſweetly gay,*
> *Leads the fair Ev'ning with her ſilver Ray,*
> *Now gilds the* Night, *now* uſhers in the Day.
>
> Prize Verſes, N°. I.

And again,

> *See!* Venus *next reveals her pleaſing Ray,*
> *Now leading on, now cloſing up the Day.*
> *Term'd* Phoſphor, *when her* Morning Beams *ſhe yields,*
> *And* Heſp'rus, *when her Ray the Ev'ning gilds.*
>
> Prize Verſes, N°. IV.

Euphroſ. Give me the Diagram once more, *Cleonicus*, there is one Thing which does not appear to me very plain yet, and that is this; you often ſay, that the Planets all move from the *Weſt* by the *South* to the *Eaſt*, and from thence by the *North* to the *Weſt* again; but if ſo, as I know they do, and ſaw very plainly in the *Planetarium*, how is it they appear to go backwards in the Heavens? I remember, you told me, I ſhould be better enabled to underſtand this Matter by a proper Diagram.

Cleon. I did, my *Euphroſyne*; and you will find it eaſy to conceive by attending to the Scheme (Plate V.) in the following Manner, *viz.*

Firſt, While *Venus* moves from her greateſt *Weſtern Elongation* A by B, D, and F, to her greateſt *Eaſtern Elongation* at G, the *Apparent Motion* is the ſame Way as the *True*; and then ſhe is ſaid to be *direct* in Motion.

Secondly, But when *Venus* moves from G by V to A, ſhe will appear to an Inhabitant of the Earth at T, to move back again from *Eaſt* to *Weſt*; which is *contrary to her true Motion*, and ſhe is then ſaid to be *Retrograde*.

Thirdly, When ſhe is about the Points G and A, ſhe will not appear to move at all for the Space of a few Days; and then ſhe is ſaid to be *Stationary*. This will more eaſily appear, if you conſider, that the Planet is ſeen by a Ray of Light coming from it to the Spectator's Eye at T, as T A, T B, T C, T D, *&c.* Now the Planet at A makes the Ray T A fall fartheſt of all from the Ray T S, which paſſes thro' the Sun, and thence the Planet, in that Situation, is ſaid to be *moſt of all elongated* from the Sun. As it paſſes from thence to B, the Ray T B comes neareſt to T S, or the Sun; and ſtill nearer, when arrived at C, and quite in Conjunction at D; and after that, the Planet carries the Ray from the Sun on the other Side towards the Eaſt, 'till it arrives to the Situation G; in which Point the Ray T G makes the greateſt Angle of Diſtance on that Side with the Ray T S. After this, as the Planet goes on from G to V, the Ray returns back, and makes the Planet *retrograde* to the Sun; and as it proceeds from V to A, the Ray goes back ſtill, 'till it arrives at its firſt Situation at T A; and then it goes *forwards* as before.

Euphroſ. I underſtand perfectly well what you have ſaid; and the ſame Things I ſee true of the Planet *Mercury*, *viz.* that he is ſeen at the greateſt Diſtance from the Sun on the Weſt by the Ray T R, which ſhews him among the Stars at Q; and on the Eaſt by the Ray T Z, by which he appears in the Heavens at X; and that during his Paſſage from R by O to Z, he is *direct* in Motion; but while he moves from Z by M to R, the Ray goes *back again*, and ſhews the Planet *retrograde* from X by W to Q. I believe I am right, *Cleonicus*, and that I ſhall be a Piece of an Aſtronomer by-and-by.

Cleon. You take Things ſo readily, my *Euphroſyne*, that I make no Doubt of your being an *Adept* in the Science ſoon; however, one Thing you have not obſerved, *viz.* that ſince *Mercury* appears to deſcribe the ſame Space in the Heavens Q X while he deſcribes very unequal Parts of his Orbit R O Z and Z M R, he muſt neceſſarily appear to move much *ſlower*, when he is *direct in Motion*, and ſwifter, when he is *retrograde*; which is ſtill more evidently the Caſe of *Venus*, where the Arches A D G and G V A are much more unequal.——Accordingly Mr. *Brown*——

She forward *moves, now pauſing,* fix'd *appears,*
Or wand'ring retrograde *among the Spheres.*
Prize Verſes, N°. IV.

But we are now arrived at the pleaſant Eminence which commands in ſo fine a Manner, the Weſtern Horizon. See the illuſtrious Star! how bright ſhe ſhines in Defiance of the Twilight, which veils, as yet, the more diſtant Stars from Sight.

Euphroſ. I ſee her, exceeding bright indeed! and, if I miſtake not, ſhe caſts a ſenſible Shadow.

Cleon. She does, indeed; the Poet might well term her the leſſer Moon.

Next Venus, *matchleſs for her brillant Light,*
Seems as the leſſer Cynthia *of the Night.*

Yea, ſo large and bright was this Planet ſome Years ago, that almoſt half the Nation took her for a *Comet.*

Euphroſ. They could not chuſe but be notable Aſtronomers that made ſuch a Miſtake. ——— But, tell me, *Cleonicus*, is not this the Star that hath ſometimes appeared in the Day-time while the Sun has ſhone?

Cleon. The very ſame; I do aſſure you, my *Euphroſyne*, I have ſeen her look forth with a ſerene Brightneſs through the Refulgence of Solar Light.

No Stars beſides their Radiance can diſplay
In Phœbus' *Preſence, the dread Lord of Day;*
Ev'n Cynthia'*s Self, tho' Regent of the Night,*
Is quite obſcur'd by his emergent Light;
But Venus *only, as if more divine,*
With Phœbus *dares in Part'nerſhip to ſhine.*

Euphroſ. Well! ſhe's a matchleſs Planet, certainly, and I long to have a more intimate Acquaintance with her; therefore let me view her Complection, and ſee what Aſpect ſhe puts on to the Aſtronomer.

Cleon. That you ſhall do inſtantly; — this Gate is of a convenient Height;—there, the Tube is fixed, *Euphroſyne*, look thro' it in that Poſition.

Euphroſ. What is it I ſee! — not that bright, that glaring Star, — if ſo, the Glaſs diveſts her of all her radiant Glory, — ſhe ſeems a Moon in Truth; — a Moon in the firſt Quarter; — large as the Moon to the naked Eye; — but ſome-what more vivid, yet ſerene; — her Horns point upwards: — But why does ſhe not appear with a full Face? —— Is the Fault in the Glaſs, or what is the Reaſon?

Cleon. The Glaſs ſhews all of her that can be ſeen; the Reaſon why you ſee only Part of her Orb enlightened is evident from the Scheme; for let us ſuppoſe ſhe were viewed from her ſuperior Conjunction at D; then, becauſe all that Part of the Body which is turned towards the Sun is ſeen alſo from the Earth; ſhe muſt then appear *wholly enlightened*, and like the *Moon at full.*

Secondly, If ſhe were viewed in the Point A or G, then but half her enlightened Face could be ſeen at the Earth, and therefore ſhe would appear as the *Moon of a Quarter old.*

Thirdly, if we ſuppoſe her at V, in her inferior Conjunction; then all her light Part being turned to the Sun, nothing but her dark Part can be towards the Earth; and, like the *New Moon*, ſhe diſappears, and can't be ſeen, even with a Teleſcope, unleſs it be in the Face of the Sun.

Fourthly, In the Points B, more than half her enlightened Diſk will appear at the Earth, and in the Point C ſtill more than before; therefore in thoſe Places ſhe will appear gibbous.

Fifthly, In the Point X, between V and A or G, ſhe will appear horned, like the Moon about 3 or 4 Days old; which is the preſent Caſe of this Planet.

Euphroſ. But there is ſomething which yet ſeems ſtrange, and that is, *Venus* is now brighteſt, and yet but a ſmall Part of her enlightened Surface is towards us; pray, *Cleonicus*, as we walk home, give me to underſtand the Reaſon thereof.

Cleon. That you will eaſily perceive from the Scheme; for, *firſt*, if the Planet be at D, ſhe will indeed be a *Full Moon*; but then ſhe will be near three times farther from the Earth T than ſhe is now at X, and conſequently, ſhe will appear 7 or 8 Times leſs there (provided ſhe could be ſeen) than at X; tho' there we ſee but a Quarter of her enlightened Side, yet that will appear larger and more brillant than her whole Hemiſphere at D.

Again, at, and about her upper Conjunction at I, ſhe cannot be ſeen by Reaſon of her Nearneſs to the Sun; but getting farther out of the Sun-Beams, ſhe augments her apparent Size, and Luſtre, till ſhe comes near the Point X, where it is greateſt of all, as before ſaid, and then ſhe is about 40 Degrees diſtant from the Sun.

Euphroſ. I preſume, *Cleonicus*, I apprehend you full well; and thus, I ſuppoſe, as ſhe approaches to V, we gradually loſe Sight of her again. ——

Cleon. Yes, unleſs ſhe ſhould chance to paſs over the Sun's Diſk, or Face (as I ſaid of *Mercury)* in her inferior Conjunction; and this ſhe will do in the Years 1761, 1769, 1996, 2004 in the Month of *June*; and in the Years 1874, 2109, 2117 in *December*; at which Times ſhe will appear a black, but beautiful Spot in the Sun.*

Euphroſ. Pray, how far is the Orbit of *Venus* from the Sun?

Cleon. About *Fifty-nine Millions of Miles*, that is, about *twice* as far off as *Mercury*; and therefore the *Light* and *Heat*, at *Venus*, will be but about a *fourth Part* of what it is at *Mercury*; and twice as great as ours.

Euphroſ. I recollect, you told me *Venus* ſpent 225 Days in revolving annually about the Sun; but pray, *Cleonicus*, has ſhe any Motion about her own Axis?

Cleon. Some ſay, ſhe has a diurnal Motion in 23 Hours; and others affirm, it is in 24 Days and 8 Hours; a very wide Difference indeed!——Such a Motion is diſcoverable only by Spots; and as I have never had it in my Power to procure a Teleſcope that would ſhew them, I can ſay but little about this Matter.

Euphroſ. What you now ſay is very extraordinary; I ſuppoſe thoſe Inſtruments are vaſtly expenſive; but if they are, one would think there were People of Fortune enough to render them more common, and to oblige every curious Perſon with the Uſe of them upon ſuch Occaſions. — But ſay, what is the Magnitude of *Venus*?

Cleon. She is computed to be a Globe of *Seven Thouſand Nine Hundred and Six Miles in Diameter*; and is therefore about 36 Times bigger than *Mercury*.

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* Of this curious Phænomenon we ſhall give a much larger and more particular Account in another Part of this Work.

Euphroſ. Well! I think we have talked her Ladyſhip out of Sight; for I can ſee her no where now.

Cleon. She is now gone to greet the jovial Sailors on the Weſtern Seas. For you know ſhe is, and ever was, the moſt of any Star admired and adored both by Land and Sea; and ſuch prodigious Veneration had the Ancients for her, that they made her their Favourite Goddeſs, and gave her all that Deity itſelf could claim. Thus one of their Poets ſings of her.

Delight of human Kind and Gods above,
Parent of Rome, *propitious Queen of Love!*
Whoſe vital Power, Earth, Air, and Sea, ſupplies;
And breeds whate'er is born beneath the Skies.
For every Kind, by thy prolific Might,
Springs, and beholds the Regions of the Light.
Thee, Goddeſs! thee, the Clouds and Tempeſts fear,
And at thy pleaſing Preſence diſappear.
For thee the Land in fragrant Flowers is dreſs'd;
For thee the Ocean ſmiles, and ſmooths her wavy Breaſt,
And Heav'n itſelf with more ſerene and purer Light is bleſs'd.

DRYD. LUCRET.

DIALOGUE IX.

Of the EARTH; *conſidered as a* PLANET.

Euphroſyne.

THE next Orbit to *Venus* in the Solar Syſtem, I ſee, is that of the Earth.

Cleon. Yes; and thus Mr. *Baker* elegantly deſcribes the Earth's Motion.

More diſtant ſtill our Earth *comes rolling on,*
And forms a wider Circle round the Sun;
With her the Moon, Companion ever dear!
Her Courſe attending thro' the ſhining Year.

UNIVERSE.

Thus alſo Mr. *Brown*;

Lo! in the Midſt, fair Earth, *our native Seat,*
And her attendant Moon their Courſe repeat.

Euphroſ. At what Diſtance is the Earth's Orbit from the Sun?

Cleon. The Earth is removed to the Diſtance of about 80 Millions of Miles, which is ſuch a convenient Situation in the Syſtem, with Reſpect to *Light* and *Heat*, as admits of no Exceſs of either. And therefore Sir *R. Blackmore*'s religious Reflection on this Subject was very judiciouſly made.

See! how the EARTH *has gain'd that very Place,*
Which, of all others in the boundleſs Space,
Is moſt convenient, and will beſt conduce
To the wiſe Ends required for Nature's Uſe.
You, who the Mind and Cauſe ſupreme deny,
Nor on his Aid to form the World rely,
Muſt grant, had perfect Wiſdom been employ'd
To find, thro' all th' interminable Void,
A Seat moſt proper, and which beſt became
The Earth and Sea, it muſt have been the ſame.

CREATION.

Euphroſ. In what Time does the Earth make a compleat Revolution in its Orbit?

Cleon. In the Space of *Three Hundred Sixty-five Days* and a *Quarter*; which makes what we call our *Solar Year*. This is called the Earth's *Annual Motion*.

Euphroſ. I remember you mentioned another Motion of the Earth, which I have not yet ſeen in the *Planetarium*.

Cleon. Yes, my *Euphroſyne*; it has another Motion about its own Axis once in 24 Hours nearly, which is the Space of a natural Day; this is called the *Diurnal Motion*, and is the Cauſe of *Day and Night*; as the *Annual* or *Yearly Motion* is that from which the various *Seaſons of the Year* reſult.

Her Central *Motions give the* Night *and* Day,
And changing Seaſons *wait her* annual *Way.*

Prize Verſes, N°. IV.

Or thus;

The Earth, obliquely circling round her Sphere,
Leads on the varying Seaſons of the Year;
Whilſt on her Axle ſhe revolves with Speed,
The Days and Nights alternately ſucceed.

Anonymous.

But the particular Manner in which the Viciſſitudes of Seaſons, and of Day and Night, are occaſioned and come to paſs, I ſhall take an Opportunity to explain to you another Time.

Euphroſ. You are very obliging, *Cleonicus*; but, pray, let me aſk you why the Orbit of the Earth is repreſented with all thoſe Diviſions and Figures about it?

Cleon. I will tell you, my *Euphroſyne*; the Orbit of the Earth is of great Conſequence, and therefore requires to be diſtinguiſhed from the reſt; for though it be the *real Path of the Earth*, it is the viſible or apparent annual Path, or Way of the Sun through the Heavens; and therefore, to denote the Sun's Place in the Heavens at any Time, the Aſtronomers have divided the whole Circle of his Motion into 360 equal Parts, which they call *Degrees*, and every 30 of theſe they call a *Sign*, of which there will be Twelve of Courſe.

Euphroſ. I obſerve, the Orbit is ſo divided as you ſpeak of; and I ſuppoſe thoſe Characters which I ſee, denote thoſe Signs reſpectively, but what are their Names, *Cleonicus*?

Cleon. The Names and Characters are as follow:

1. ♈, *Aries*, the Ram.
2. ♉, *Taurus*, the Bull.
3. ♊, *Gemini*, the Twins.
4. ♋, *Cancer*, the Crab.
5. ♌, *Leo*, the Lion,
6. ♍, *Virgo*, the Virgin.
7. ♎, *Libra*, the Ballance.
8. ♏, *Scorpio*, the Scorpion.
9. ♐, *Sagittarius*, the Bow-man.
10. ♑, *Capricornus*, the horned Goat.
11. ♒, *Aquarius*, the Waterer.
12. ♓, *Piſces*, the Fiſhes.

Euphroſ. What is the Reaſon they have ſuch Names given them?

Cleon. Theſe are the Names of ſuch Conſtellations of Stars as formerly occupied the Parts of the Heavens where the Signs are, but thoſe Stars are now removed forwards to other Signs, and have left only their Names behind; as we ſhall hereafter ſee.

Euphroſ. I think this Orbit, thus divided into Signs, is what you call the *Ecliptic* on the Planetarium; is it not, *Cleonicus?*

Cleon. The very ſame, my *Euphroſyne*; it is called the *Ecliptic*, becauſe, as it is the viſible Path of the Sun through the Heavens, all the *Eclipſes* muſt happen therein, as you will ſometime hence obſerve more ſenſibly.

Euphroſ. As there are 360 Degrees in the Ecliptic, and but 365 Days in the Year, I find the Earth muſt paſs over one of thoſe Degrees very nearly each Day.

Cleon. Yes, my *Euphroſyne*, it does ſo; each Degree is ſuppoſed to conſiſt of 60 *Minutes*, thus marked (′); and each *Minute* of 60 *Seconds* (″); each Second of 60 Thirds (‴); and ſo on. And the Earth each Day moves, at a Mean, 59′ : 8″ of a Degree.

Euphroſ. Well! I ſhall, by-and-by, not only *think*, but *ſpeak* like an *Aſtronomer*; as you make the firſt Sign (and conſequently the Beginning of the Ecliptic) to begin with the firſt Degree of *Aries*, pray, to what Day of the Year does this Point anſwer?

Cleon. According to the preſent New Style, it anſwers to the 21ſt of *March*; when the Sun is ſaid to be in the *Vernal Equinox*, for Reaſons you will hereafter be acquainted with.

Euphroſ. Is the Orbit of the Earth a perfect Circle?

Cleon. No, it is not; though it differs not much from it, yet it makes a ſenſible Difference in the Earth's Motion; for the Orbit being a little Eliptical, will cauſe that the Sun will be nearer the Earth at one Time than another; and that will make the Earth move a ſmall Matter faſter in one Part than it does in another, and conſequently that it will take up more Time, or a greater Number of Days in deſcribing one half of its Orbit, than it requires for the other; thus in paſſing through the ſix Signs ♎, ♏, ♐, ♑, ♒, ♓, it takes up 8 Days leſs, than in paſſing through the other ſix ſummer Signs, as you may underſtand by placing the Months and Days as follow:

Summer Months.		Winter Months.	
In *March*	10½	*September*	7
April	30	*October*	31
May	31	*November*	30
June	30	*December*	31
July	31	*January*	31
Auguſt	31	*February*	28
September	23	*March*	20½
Summer	186½		178½
Winter	178½		
Difference	8 Days.		

Euphroſ. Well, I never obſerved this before, though it be ſo evident from the common Almanack; but, *Cleonicus*, if our quicker Motion in the Winter proves we are then nearer the Sun, how comes it to paſs the Sun then ſeems fartheſt from us, and that ſo much the coldeſt Seaſons of the Year?

Cleon. Why, indeed, my *Euphroſyne*, theſe *Phænomena* are a little *paradoxical*, till you come to ſee this Matter ſet in a proper Light under all its Circumſtances, and then you will readily allow it muſt be ſo.

Euphroſ. But if the Sun be neareſt in the Winter, how is it, that it does not then appear larger than in the Summer?

Cleon. That is well obſerved, Siſter; but the Difference of Diſtance is ſo very ſmall as to make no ſenſible Difference in his apparent Magnitude; yet, were you to meaſure it with a *Micrometer* in a Teleſcope, you would find, that when the Sun is in the 8th Degree of ♑, his Diameter would meaſure 1967″, and when in the 8° of ♋, it meaſures only 1900″; leſs by 67″ than before, which is near a 30th Part of the Whole. You will at preſent believe what I ſay; but when we come to the practical Part of Aſtronomy, you will find it true by Experiment.

Euphroſ. You are very liberal in promiſing me great Things, *Cleonicus*, I ſhall be very happy in finding myſelf capable of them—But, pray, tell me what you know of the Form and Magnitude of the Earth.

Cleon. I will, my *Euphroſyne*; and therefore, firſt, as to the Figure or Form of the Earth, it is nearly that of a Globe or Sphere, as has been found by modern Diſcoveries moſt perfectly.

Euphroſ. Pray, in what Manner do you find this true, by Experiment?

Cleon. Several Ways, Siſter, as (1.) If you go directly North or South, you raiſe or depreſs the *North-Star* very ſenſibly, and always to equal Heights for equal Diſtances that you go; this Experiment I will one Day or other ſhew you. Now were you to walk ever ſo far on a Plane, the ſaid Star would ever appear of the *ſame Height* above the Horizon. (2.) If you ſtand on the Sea-coaſt, you will evidently obſerve the Convexity of the Surface of the Ocean; but more particularly you will be convinced of this, by obſerving a Ship ſailing directly from you; where you will gradually loſe Sight, firſt, of the Hull or Body of the Ship; and then of the ſeveral Sails; and, laſtly, the *Tops* of the *Maſts* diſappear. Now, were the Surface of the Sea a *Plane*, ſuch Appearances could never happen. (3.) The Shadow of the Earth in an *Eclipſe* of the Moon is obſerved to be *circular*, which it could not be unleſs it proceeded from a ſpherical Body.

Euphroſ. I make no Queſtion now of the globular Figure of the Earth, you have given ſufficient Proofs of it; and becauſe I think it a Matter ſo eaſily, and ſo fully proved by the two Obſervations you firſt mentioned; I wonder very much the Ancients ſhould be ignorant of it, or ever make any Difficulty about it.

Cleon. I think, indeed, it is a Matter of Wonder, for the Sages of Antiquity to have ſo great a Character for Wiſdom as they generally have, and yet were ſo ignorant of the eaſieſt and plaineſt Things in Nature; they moſt of them thought the Earth was a plain Surface, like a round Table, and that all below it was *Hades* or *Hell*, or, in ſhort, ſomething they knew not what; and whither the Sun, Moon, and Stars went to, and whence they came, each Evening and Morning, they could not tell. Yea, ſo very groſs were their Conceptions of theſe Things, that ſome of them thought the Sun, *&c.* did actually deſcend into the Weſtern Ocean, at Night, and aroſe out of the Eaſtern Ocean in the Morning. Thus *Ovid*,

The Sun did now to weſtern Waves retire,
In Tides to temper his bright World of Fire.

And it is extreamly diverting to hear *Epicurus* gravely recounting the ſeveral Methods by which to ſolve the daily Miracle of a New Sun kindling up the Lamp of Day, which was extinguiſhed every Night in the Waters of the *Hibernian* Seas. For thus he harangues us,

And Day may end and tumble down the Weſt,
And ſleepy Night fly ſlowly up the Eaſt;
Becauſe the Sun, having now perform'd his Round,
And reach'd, with weary Flames, the utmoſt Bound
Of finite Heaven, he there puts out the Ray,
Wearied and blunted all the tedious Day
By hind'ring Air, and thus the Flames decay:
Or elſe, becauſe the Fires abſorb'd at Night
There join again, and ſcatter vigorous Light.
Thus when the Morning Sun begins to riſe,
It's Flames lie ſcatter'd o'er the Eaſtern Skies;
Then gather'd to a Ball; and this we view
From Ida's *Top: this Fame reports as true.*
Nor is it ſtrange, that numerous Seeds of Fire
Should to the Eaſtern Quarter ſtill retire,
Still every Day return and make a Sun. CREECH.

Euphroſ. As they had ſuch aukward Notions of Things they every Day ſaw, I fancy it muſt be merry to hear them diſcourſe of ſuch Things as they never ſaw; for Inſtance, of their *Heaven* and *Hell*, and their different Opinions of departed Spirits, *&c.*

Cleon. Very much ſo indeed; they imagined all above the Sky was Heaven, and all below the Earth was Hell, as I ſaid but now; nay, they went ſo far as to find out the Way to Hell, if you believe their Poets. Thus *Virgil* deſcribes *Æneas*'s Deſcent thither.

Theſe Rites perform'd, the Prince without delay,
Haſtes to the nether World, his deſtin'd Way.
Deep was the Cave; and downward as it went
From the wide Mouth, a rocky rough Deſcent,
And here th' Acceſs a gloomy Grove defends,
And here th' unnavigable Lake extends. ÆNEID VI.

And in another Place;

To th' Shades you go a down-hill eaſy Way;
But to return and re-enjoy the Day!
That is a Work, a Labour———

Thus alſo *Ovid*,

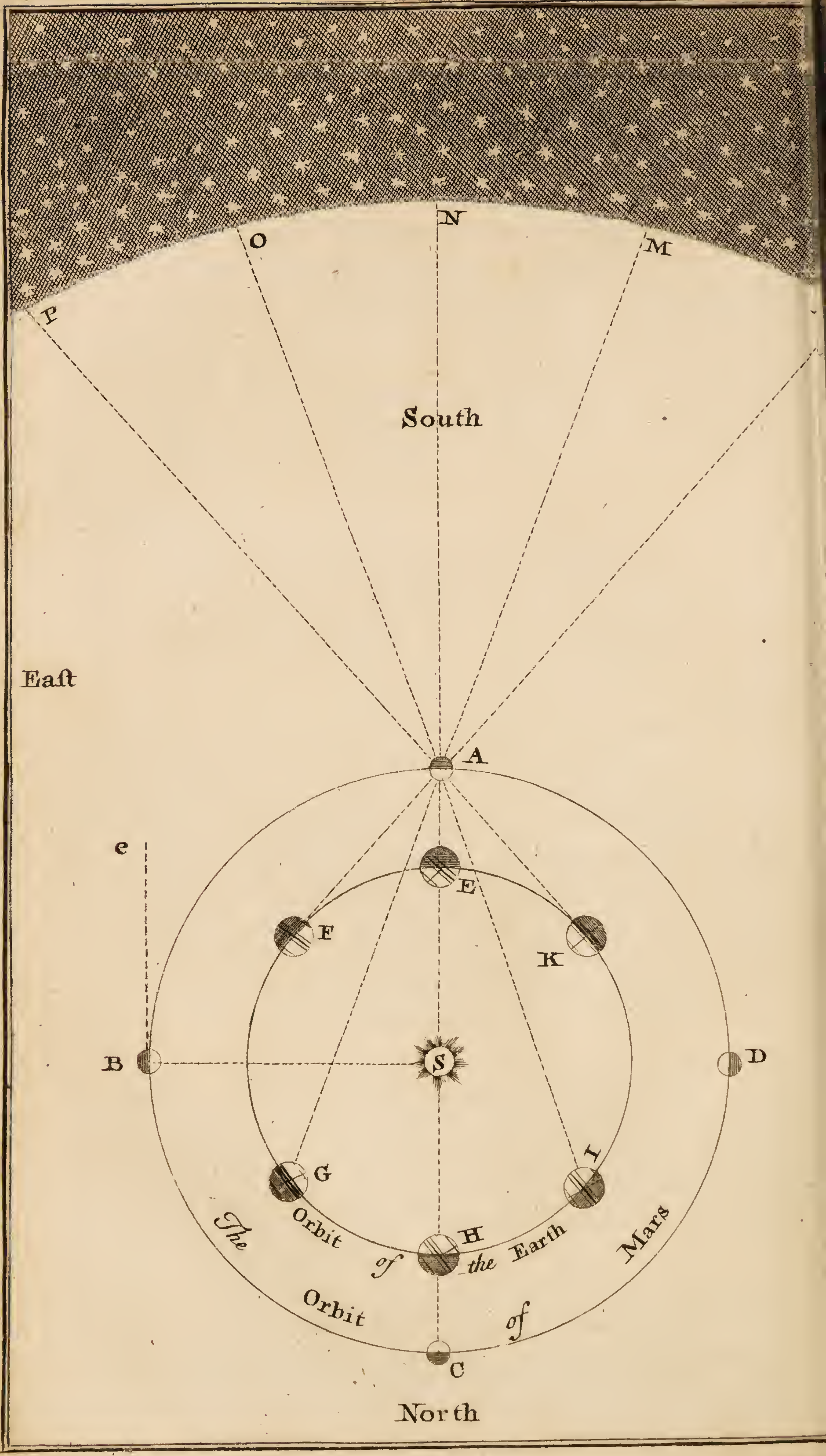
Between thick baleful Yews, the dreary Way
To loweſt Hell, thro' diſmal Silence lay;
There Stygian Miſts infect the Road, and there
New Ghoſts, and thin unfuneral'd Souls appear.

Euphroſ. No more of this, *Cleonicus*; ſuch horrid Images ſhock me; it is a miſerable Thing to be a *mere Heathen!*—

Cleon. It it ſo,—without Honeſty; but the Figure of the Earth is not the Subject of Revelation, my *Euphroſyne*; and ſome of the Fathers of our Church have as gravely defended the *heatheniſh Figure* of the Earth, as if they had been the Deſcendants of *Ptolomy* himſelf. Nay, not many Ages ſince, the Doctrine of the *Antipodes* was zealouſly oppugned as a *damnable Hereſy*; and Hiſtory informs us, that the learned *Spigelius*, Biſhop of *Upſal*, ſuffered Martyrdom at the Stake in its Defence.

Euphroſ. Well, I could never have thought the Figure of the Earth had been ſuch an important Article of Faith. It is to be hoped we underſtand Religion better now a Days; for though I can ſcarce remember every one of the 39 Articles of our Faith, yet I am pretty well ſatisfied, neither the *Form* nor *Motion* of the Earth are any Part of any of them.

Cleon. They are not; and our Principles and Notions of Religion are much more correct and rational than they were formerly; and to what is this owing, my *Euphroſyne?* To our having a more correct and rational Philoſophy; you will find it



N
O
M
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South
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B
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D
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I
H
C
The Orbit of Mars
Orbit of the Earth
North

it a never-failing Maxim, that the better you underſtand *Philoſophy*, the better you will underſtand *Religion.* But this by the Way——

Euphroſ. Then let us return to our Subject; and ſee if I can underſtand what remains of the Philoſophy of the Earth. Pray, what is the Bulk or Magnitude of it?

Cleon. It is about *twenty-five Thouſand* and *twenty Miles in Circumference.*

Euphroſ. Well, that is a large Circuit, indeed; *Lord Anſon* might very well employ four Years in *going round the World.*

Cleon. True; but you muſt conſider, in ſuch Voyages it is impoſſible to go the neareſt Way; and they who go round the World, as you call it, go many Thouſand Miles more than the Earth is Round, as we ſhall hereafter ſee, when you come to the Uſe of the terreſtrial Globe—And this you obſerve, is another infallible Proof of the Earth's being of a ſpherical Form; for you may ſail almoſt upon a Circle from *Plymouth* to the *Antipodes*, and find that Diſtance about half the Number of Miles I before mentioned.

Euphroſ. You have fully convinced me the Earth is a *Globe*; but what is the Diameter of the Earth in Miles? I ſuppoſe you can tell that, as well as how much it is round.

Cleon. Juſt as well; the Diameter of every Circle is in reſpect to its Circumference nearly as 7 to 22, whence that of the Earth will be about 7960 Miles; and it is very remarkable, that the Planet *Venus* is much about as big, for the Diameter of that Planet is computed to be about 7906 Miles, which is but a Trifle leſs than that of the Earth.

Euphroſ. So that if we were placed in the Planet, we ſhould view the Earth as large as the Evening-ſtar, but not ſo bright—

Cleon. You would ſo, my *Euphroſyne*; but the Phaſes of the Earth would reſemble thoſe of *Mars*, and not of *Venus.* And I dare ſay you know the Reaſon of it.

Euphroſ. Becauſe the Orbit of the Earth is exterior to that of *Venus*—But one Thing I have often thought to aſk you, is, why the Earth and all the Planets move always one Way, and in ſo regular a Manner? Alſo how they, being ſuch large and heavy Bodies, can keep moving round at the ſame Diſtance, and not fall directly to the Sun?

Cleon. Sir *Iſaac* has ſhewn perfectly well how they move in Curves by a proper Compoſition of two Forces acting upon them at once; and the Direction of their Motion was at the Pleaſure of the firſt Mover, for nothing depends on that; therefore, Sir *Richard Blackmore*'s Banter on the Philoſophers upon this Subject, proved more his *own* than *their Ignorance*, when he thus ſneers them.

This Problem, as Philoſophers reſolve,
What makes the Globe from Eaſt to Weſt revolve?
What is the ſtrong impulſive Cauſe, declare,
That rolls the pond'rous Orb ſo ſwift in Air?
To their vain Anſwers will you have Recourſe,
And tell us 'tis ingenite active Force?
Mobility, or native Power to move,
Words which mean Nothing, and can Nothing prove.
CREATION.

Thus alſo the Author of *Univerſal Beauty*;

Say, why this Globe has its appointed Place?
And why not vagrant thro' the boundleſs Space?
Why here prefer'd, ſagacious to refuſe
What thwarts Propriety, Convenience, Uſe?
Why not more Neighbour to the burning Ray,
Or more remote from the declining Day?
Or here not ſedentary, fix'd and ſtill?
Admoniſh'd by no Voice, obſequious to no Will.
Or moving, why in circling Eddies round,
And not progreſſive thro' th' immenſe Profound?
Or endleſs, why the dizzy Drunkard reels,
And round the Sun its annual Motion wheels?
Whence is that innate delegated Power,
Central to ſpin the ſwift diurnal Tour?

Euphroſ. Why truely, I think a Woman, no wiſer than myſelf, might venture to ſay, that if the *Poetry* of theſe Lines were no better than the *Senſe*, they would be worth no Body's Notice. Theſe Gentlemen might juſt as well aſk, why the Hands of a

Clock move at all? why they move in a Circle? why they move to the right Hand, not to the Left? why they move one faſter than the other? why each one always moves an equal Pace? in ſhort, why one is longer, or bigger than the other? theſe Queſtions would be juſt as pertinent, and ſhew their Skill in Mechanics equal to that in Philoſophy.

Cleon. What you have obſerved is extremely juſt, my *Euphroſyne*; People often affect to be wiſe above the Power of human Nature, they are told that *Gravity* gives Motion to all Bodies, but they, forſooth, muſt know *what Gravity is*, or elſe condemn it for an *occult Quality*; very good Logic this, Siſter, ſince Gravity is *not* a *Quality*, nor is it at all *occult*. But we ſhall wave ſuch idle Curioſity and purſue the uſeful Speculation of what is *permitted us to know*. Therefore the Planet *Mars* ſhall be the Subject of our next Confabulation.

DIALOGUE X.

Of the PLANET *MARS*.

Euphroſyne.

I Have juſt been out to view the Sky, and all Things above promiſe a clear and Star-light Evening to Night.

Cleon. I have obſerved it; the Heavens have at preſent a benign Aſpect, and will, if the Clouds forbear to riſe, be favourable to our Deſign.——

Euphroſ. That is, to take a View of the Planet MARS, *Cleonicus*; was not that the Concluſion of laſt Night's Conference?

Cleon. Yes, it was; *Mars* is the next Planet in the Syſtem; but of him neither the Poets nor the Philoſophers have much to ſay, as a *Planet*; tho' he bears an illuſtrious Character among the *Heathen Divinities*. Yet is he not wholly neglected by the Moderns; for thus one:

> *See*, MARS *alone runs his appointed Race*,
> *And meaſures out exact his deſtin'd Space*;

Nor nearer does he wind, nor farther ſtray,
But finds the Point whence firſt he roll'd away.

BAKER's Univerſe.

Thus another;

And higher ſee! in thrice our annual Space
Revolving, MARS *conclude his longer Race.*

Mr. BROWN.

Euphroſ. What, does the Poet ſay, *Mars* is two Years revolving in his Orbit about the Sun?

Cleon. Yes; but Poets are ſeldom to be depended on for Strictneſs of Truth. *Mars* runs his Race in *Six Hundred Eighty-ſeven Days*, which wants 43 Days of Two Years.

Euphroſ. Pray, what Diſtance is *Mars* from the Sun?

Cleon. About *One Hundred and Twenty-three Millions of Miles*; that is, half as far again from the Sun as the Earth: whence the *Light* and *Heat* of the Sun at *Mars* is not quite *half ſo much as with us*; for it is in Proportion as 43 to 100.

Euphroſ. Be ſo good, *Cleonicus*, as to delineate the Orbit of this Planet about the Sun, as you did thoſe of *Venus*, *Mercury*, and the Earth; for my Underſtanding is much aſſiſted thereby.

Cleon. I will do it immediately, and that of *Mars* will be ſufficient for *Jupiter* and *Saturn*; for the *Phænomena* of the three ſuperior Planets are the ſame in each of them.—* In this Diagram, then, you ſee the Orbit of *Mars*, and the Planet in the Poſitions A, B, C, D; within the Orbit of *Mars*, you ſee the Earth's Orbit, and the Earth at E, F, G, H, I, K; and in the Center S is the Sun.

Euphroſ. This is all very evident; and here you need not repeat what you have before told me of the general Appearances of this Planet, when you deſcribed the whole Syſtem to me; but only ſuch as are peculiar to the Planet whoſe Orbit lies about or beyond that of the Earth. And pray, what are theſe?

Cleon. They are not many, and are very eaſy to be underſtood; for ſuppoſe *Mars* at A, and the Earth at E, directly between it and the Sun, then will all the enlighten'd Hemiſphere of the

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* The Reader is here to keep his Eye on Plate VII. during the above Deſcription of the ſeveral Phænomena of the Planet *Mars*.

Planet be turn'd to the Earth, and it appear wholly enlighten'd like the *Full-Moon.* When the Planet is at B, ſuppoſing your Eye at *e*, you ſee one half of his Surface enlighten'd; but if your Eye be removed from *e* to E it is then nearer to, or more towards the Sun, and therefore you will then ſee more than half the Planet enlighten'd, or he will appear *gibbous*, as they call it, like the Moon a few Days before or after Full. From hence he goes on to C, where it would again appear wholly enlighten'd, were it not in the ſame Part of the Heavens with the Sun, and ſo not ſeen at all. At D again it is gibbous, and ſo upon the whole you obſerve the *Phaſes* of a ſuperior Planet are not ſo various as thoſe of an inferior one; and in *Jupiter* and *Saturn*, which are very remote from us, nearly the whole Surface will appear conſtantly illumined. I make no Doubt but you ſee in general the Reaſon of all that I have ſaid from the Draught.

Euphroſ. I flatter myſelf I do; for the farther the Planet B is removed in that Situation from S, the nearer we may ſay the Point E is to the Sun at S, and conſequently the Planet will appear leſs gibbous or more enlightened in that Proportion.

Cleon. That is the very Thing, Siſter; but all the Phaſes of the Planets are very naturally repreſented in the Planetarium by placing a Candle in the Center, and putting the Planets in Motion, firſt the inferior ones, then the ſuperior; you will ſee them illumined in the ſame Manner by the Candle as they are in the Heavens by the Sun; and this ſhall be our Amuſement another Time.

Euphroſ. You take a great deal of Trouble about me, *Cleonicus*, which much endears you to me— but, in the mean Time, what other Peculiarities belong to the ſuperior Planets?

Cleon. One Thing more only, and that is, a ſuperior Planet has *one Conjunction only*, at C; and an *Oppoſition* at A, which an inferior Planet has not, as I have formerly obſerved to you.

Euphroſ. This is indeed very plain; if I view the Planet *Mars* at C from the Earth at E, I ſee him in the ſame Part of the Heavens with the Sun at S; and if I view him at A, I ſee him juſt in the oppoſite Part; and therefore when the Sun ſets, I may ſometimes ſee *Mars*, *Jupiter*, and *Saturn*, riſing; which I well remember you ſhew'd me, could not be obſerved of the inferior Planets *Mercury* and *Venus*. But pray, *Cleonicus*, what mean all thoſe dotted Lines which paſs from the Earth in its ſeveral Poſitions thro' the Planet at A away to the Stars in the upper Part of the Plate?

Cleon. They are to ſhew how you are to underſtand that the ſuperior Planets all move (like the inferior ones) in Appearance ſometimes *forward*, ſometimes *backward*, and are ſometimes *ſtationary* for a While.

Euphroſ. Then I ſuppoſe each of thoſe dotted Lines repreſents a *Ray of Light* coming from the Planet to the Eye, and by which we ſee his apparent Place among the Stars in the Sky; is it not ſo, *Cleonicus?*

Cleon. You have hit the Caſe as nicely as if you were *Copernicus*'s Great-great-grand-daughter—— And I ſee from thence that you will have no Difficulty to underſtand this *Phænomenon.* For ſuppoſing the Earth at F, and the Planet at Reſt in its Orbit at A, it will be projected or ſeen by a Ray of Light among the Stars at L; when the Earth arrives at G the Planet will appear at M by the Ray GM; and in the ſame Manner at H, I, and K, it will be ſeen among the Stars at N, O, P, and therefore while the Earth moves over the large Part of it's Orbit F, H, K, the Planet will have an apparent Motion from I to P among the Stars, and this Motion is from *Weſt* to *Eaſt* the ſame Way with the Earth; and ſo the Planet is ſaid to be *direct* in Motion all this Time. I believe you underſtand me, Siſter.

Euphroſ. Surely I muſt, when the Thing is ſo obvious; and I am of Opinion I know what you are going to ſay next, *Cleonicus.*

Cleon. Why indeed, my *Euphroſyne*, when the Planet has gone as far as it can *forwards*, 'tis natural to ſuppoſe it will there *ſtop* a *While* (as it were to breathe) and then return *back again.* For becauſe the Ray of Light at K does nearly coincide with the Earth's Orbit a little Way on one Side and on the other, therefore all the While the Earth is paſſing thro' this ſmall Part, the Ray will have the ſame Poſition nearly, and conſequently ſhew the Planet at Reſt at P, for that ſhort Space of Time; in which Caſe it is then ſaid to be *ſtationary.*

Euphroſ. I was a little out in my Conjecture, having almoſt forgot what you told me heretofore of the *Stations* of *Venus* and *Mercury.* But now I am certain what muſt next follow from the Scheme, and will anticipate your Deſcription of the *Retrograde Motion*; for I plainly enough ſee that when the Earth moves on from K to E the Planet muſt appear to return from P to N, and while the Earth moves from E to F the Planet will proceed ſtill retrograde to L, and there again be ſtationary; is not all this right, *Cleonicus?*

Cleon. Indeed, my *Euphroſyne*, it is; I could not have better expreſſed it myſelf; you will by-and-by be an *Adept* in Aſtronomy.—— And I queſtion not but you obſerve at the ſame Time, that ſince the Part of the Orbit which the Earth deſcribes in paſſing thro' F H K is much greater than the Arch K E F, and the Space L P which the Planet deſcribes in its direct and retrograde Motion is the ſame; therefore the *direct Motion* is *very ſlow* from L to P, in Compariſon of the *retrograde Motion* from P to L, which is perform'd in much leſs Time.

Euphroſ. All you have ſaid, I ſee the Reaſon of from the Diagram as plainly as any Thing can make it.

Cleon. You don't know that, perhaps; I have another Method yet, my *Euphroſyne*, to convey the Idea (in a more lively Manner) of the *direct* and *retrograde Motions* and *Stations* of the Planets, by ſhewing you the Thing in Reality in the Planetarium juſt as it appears in the Heaven to our Eye, when we have done with the ſuperior Planets.

Euphroſ. I think 'tis ſtrange then, if I do not underſtand it at laſt; I imagine you look upon this as a difficult Point for an *aſtronomic Tyro* to comprehend, ſince you take ſo much Pains with me about it; do you not *Cleonicus?*

Cleon. Why, I can't ſay but I think it quite neceſſary to have a right Underſtanding of this Affair, as it is a principal and very intereſting *Phænomenon*, and what very few People have a clear Notion of. And indeed I muſt tell you, that as the *Geometricians* have one Propoſition in *Euclid* which they call the *Aſs*'s *Bridge*, which their Pupils muſt paſs before they can be ſuppoſed to underſtand any Thing in that Science; ſo you muſt look upon this Problem in Aſtronomy in the ſame ludicrous Light, and think your ſelf not initiated into the Myſteries of *Urania*, 'till you can clearly account for this *Phænomenon*.

Euphroſ. Well, I doubt not but when you ſhew me this in the *Planetarium*, I ſhall have a clearer and moſt compleat Idea of it; you ſee, I have Courage enough, *Cleonicus.*— But at preſent, I muſt aſk you the Reaſon of one Thing, and that is, why you place the Planet at Reſt in its Orbit at A, ſince it is in Reality always in Motion?

Cleon. The Reaſon is, becauſe I would make the Thing eaſier for you to apprehend from the Diagram; for the *Phænomenon* is the ſame in it ſelf, whether you ſuppoſe the Planet to be at Reſt or in Motion, it only makes a Difference in the *Time* and *Place*, *when* and *where* it happens; as you will be convinced of another Time.

Euphroſ. Very good, *Cleonicus*; 'till then we will wave this Subject. I want to have a Sight of this Planet; how far is he this Night from the Point A of his Oppoſition to the Sun?

Cleon. Not a great Way; and therefore he may be very opportunely viewed this Evening, to that End I have prepared and fixed the Teleſcope for your Sight.

Euphroſ. The Heavens clear up, the Stars begin to appear more and more bright; pray, which is *Mars* among them all?

Cleon. It is that bright Star which you ſee high in the Heavens, a little to the Eaſt of the Seven Stars; he appears of a *reddiſh Hue*, and ſteady Countenance.

Euphroſ. I ſee him; pray, level the Teleſcope to him.—

Cleon. I will,—— It is done, look thro' it.——

Euphroſ. I ſee him very plain,— but he appears very ſmall,— much ſmaller than *Venus*— and redder, ——with almoſt a round Face;—— but I can ſee no Spots or any Thing on him,—— he is juſt paſſed off the Glaſs.——

Cleon. You rightly obſerve that he appears very ſmall; for he is indeed much leſs than the *Earth* or *Venus*, being but *Four Thouſand four Hundred and forty-four Miles* in Diameter. It is therefore near *Six times leſs* than the Earth.

Euphroſ. Does this Planet turn round upon its own Axis?

Cleon. Some Aſtronomers ſay they have obſerved divers Spots on his Surface, and from their Motion thereon have ſuppoſed, that he revolves about his Axis in 24 Hours and 40 Minutes; and if ſo, his Days and Nights are much of the ſame Length with ours. But our Teleſcope, as you obſerved, is not ſufficient to diſcover theſe Spots.

Euphroſ. How comes *Mars* to have ſuch a ruddy Complexion?

Cleon. This is ſomewhat uncertain; but in all Probability, from a peculiar Sort of Matter of which this Planet conſiſts, which reflects the *red-making Rays* of Light; or from a very thick Atmoſphere about him, which we very well know will produce the ſame Effect. But, be this as it will in Philoſophy, 'tis certain this his *ſanguine Complexion* entituled him to the Poſt he bore among the ancient *Pagan Deities.*

Euphroſ. You mean his being reputed the *God of War and Armies*, I ſuppoſe.

Cleon. Yes; and they repreſented him riding on an high Chariot drawn by two furious Horſes, *Fear* and *Terror*, driven by his Siſter *Bellona*, the Goddeſs of War; he was covered with *Armour*, and held a *Spear* in one Hand, and brandiſhed a *Sword* in the other, threatning Ruin and Deſolation to the World. *Virgil* thus deſcribes his Career,——

MARS *in the Middle of the ſhining Shield*
Is grav'd, and ſlides along the liquid Field.
The Diræ *come from Heav'n with quick Deſcent,*
And Diſcord *dy'd in Blood, with Garments rent,*
Divides the Preſs; her Steps Bellona *treads,*
And ſhakes her Iron Rod above their Heads.

Æneid. 8.

Euphroſ. However he might be equipped on Earth in Proxy, I fancy he is alone in the Heavens, for I ſaw nothing but himſelf in the Teleſcope.

Cleon. Very true, my *Euphroſyne*, he has there no Attendants, no *Satellites*, no *Heralds*, tho' himſelf be there moſt glorious. He walks his Round in eternal Solitude, and is the only Planet above *Venus* that traverſes the Heavens deſtitute of Arms and Attendance.

Euphroſ. It was not, then, with the greateſt Propriety that he was elected *God of War*; but, alaſs! he little thought of the Honours he bore, and how terrible he was to Mortals in his Neighbour-Planet the Earth.

Cleon. You hit the Poet's Thought,——

In larger Circuit rolls the Orb of MARS,
Guiltleſs of ſtern Debate and waſtful Wars,
As ſome have erring taught; he journies on,
Impell'd and cheriſh'd by th' attractive Sun;
Like us, his Seaſons *and his* Day *he owes*
To the vaſt Bounty which from Phœbus *flows.*
PRIZ. VERS. *Numb.* IV.

DIALOGUE XI.

Of the PLANET *JUPITER.*

Euphroſyne.

I Remember, in the Planetarium, the next Planet above *Mars* was *Jupiter*, when you repreſented the *Copernican Syſtem.*

Cleon. Yes, it was; the great and wondrous Orb of *Jupiter* rolls next; accordingly Mr. *Baker* thus deſcribes it,—

Yet more remote from Day's all-cheering Source,
Large JUPITER *performs his conſtant Courſe:*
Four friendly Moons, with borrow'd Luſtre, riſe,
Beſtow their Beams, benign, and light his Skies.
Univerſe.

Euphroſ. Pray, *Cleonicus*, let me ſee the Plate of the *Solar Syſtem.*

Cleon. Here it is.——

Euphroſ. The Orbit, then, of *Jupiter*, I ſee; but is it really ſituated ſo far from the Sun with reſpect to the Earth, as it is there drawn?

Cleon. Yes, my *Euphroſyne*; *Jupiter* is a little above *five times* farther from the Sun than the Earth; that is, he is *Four Hundred and twenty-four Millions of Miles* from the Sun; and ſo his *Light* and *Heat* is about 32 times leſs than ours.

Euphroſ. Well, ſure, if there be any Inhabitants in *Jupiter*, they are doomed to a very cold and gloomy State; I quite ſhudder at the Thoughts of it!

Cleon. They are very cold and dark indeed, when compared with us; but their Natures are ſuited to it, and ſo can ſuffer nothing on that Account. Our Degree of Light and Heat would be as intolerable to them, as theirs of Cold and Darkneſs would be to us.

Euphroſ. If I miſtake not, I have read that *Jupiter* is the largeſt of all the Planets.

Cleon. He is ſo; nay, he is bigger than all the other Planets put together; being no leſs than *Eighty-one Thouſand One Hundred and Fifty-five Miles* in Diameter, which renders him above *a Thouſand Times* larger than our Earth.

Thus Mr. *Brown:*

Then Jove, *prodigious Planet of the Skies!*
His Orb preſents, of huge amazing Size,
In Bulk none equals his enormous Maſs;
The whole joint Syſtem his Contents ſurpaſs.

N°. III.

Euphroſ. Pray, how long is *Jupiter* revolving his prodigious Orb about the Sun?

Cleon. About twelve Years; or more preciſely, in *Four Thouſand three Hundred and Thirty Days and an Half.* Conſequently his *Summer* and *Winter*, and other Seaſons, are almoſt twelve times as long as ours.

Euphroſ. And what Length are his *Days* and *Nights*, *Cleonicus?*

Cleon. Some have determined a Motion about his own Axis, in the Space of 9 Hours 56 Minutes, from a Spot they have obſerved to paſs over the Diſk, or Face, of *Jupiter* in half that Time.

Euphroſ. Then the Days and Nights are but *Five Hours long*, I find, notwithſtanding his Years are ſo tedious.

Cleon. They are ſo very ſhort, indeed; and the Plane of *Jupiter*'s Orbit being but very little inclined to that of the Ecliptic, there is but very little Difference between the Length of Days and Nights throughout the Year. Of his Days and Seaſons thus Mr. *Brown:*

In ampler Compaſs Jove *conducts his Sphere,*
And later finiſhes his tedious Year.
Yet ſwiftly on his Axle turn'd, regains
The frequent Aid of Day to warm his Plains.
Priz. Verſ. N°. IV.

Euphroſ. I obſerve, from the Diagram, that he as well as *Mars*, has his *Conjunction with, and Oppoſition to, the Sun*; and that he is alſo ſome-what nearer to the Earth at the Oppoſition, than when in Conjunction.

Cleon. Yes, my *Euphroſyne*, you rightly obſerve, that he has all the Particulars which were related of *Mars*; he is ſometimes conjoined with, ſometimes oppoſed to the Sun; ſometimes *Direct* in Motion, ſometimes *Retrograde*, and at other times *Stationary:* He is indeed nearer the Earth at one Time than another by the Difference of the Diameter of the Earth's Orbit; but that is ſo inconſiderable, that his apparent Magnitude is very little varied thereby. And it is almoſt all one if *Jupiter* be viewed from the Earth, or the central Sun itſelf.

Euphroſ. But when he is neareſt that will be the beſt Place to obſerve him with a Teleſcope.

Cleon. You are very right, my *Euphroſyne*; he is then apparently one-third Part bigger, and ſhines with the greateſt Luſtre, and may be conveniently viewed at all times of the Night, when the Weather is clear.

Euphroſ. And pray how is he ſituated in his Orbit this Evening? I hope in ſuch a Part as will render him viſible.

Cleon. You have your Wiſhes; if you now ſtep out, you will ſee him almoſt culminating, or in the higheſt Point of the Zodiac, ſhining with a large, pale, and ſteady Luſtre.

Euphroſ. I'll immediately go, —— I believe I ſee him, —— is it not that very large pale Star, on the Left-hand of the *Seven Stars*, and nearly South-weſt?

Cleon. That is the Planet; 'tis that mighty *Jove*, whom the Heathen adored as the ſupreme Lord of all; and indeed he appears, compared with the other Stars, to ſit as it were, on the Throne of the Heavens, and to preſide with Majeſty and Glory over all the ſtarry Regions.

Euphroſ. I long to ſee him as much as ſome People do to ſee the King. I hope your Teleſcope is in Order, ſince the Air is ſo clear and ſtill to Night.

Cleon. There could not be a finer Evening for the Purpoſe. This Afternoon I carefully cleaned the Glaſſes, and fitted the Teleſcope for Uſe; let us therefore take it and go out.

Euphroſ. I'll follow you, *Cleonicus*, pray be expeditious in fixing the Glaſs. ——

Cleon. Truſt me, *Euphroſyne*, for that; —— the Tube is now well fixed, and you may view in his Face equal Grandeur and Serenity.

Euphroſ. Grandeur, indeed, I think! —— for he appears exceeding large —— and equally ſerene, as you ſaid, —— I cannot but admire his wondrous Aſpect, —— he appears with a full enlightened Face —— I ſee none of thoſe Spots that you ſpoke of juſt now —— his Face ſeems all over-ſpread with a ſoft, a ſteady and uninterrupted Glory. —— But what are thoſe *Belt-like* Appearances, which I ſee go acroſs his Body in one or two Places?

Cleon. They are call'd his *Belts*, indeed; but what they are is not poſſible to determine, nor eaſy to conjecture. Sir *Iſaac Newton* ſpeaks of them as *Clouds*, but tho' they vary their Magnitude, and Diſtances among themſelves, yet while they have the ſame conſtant Appearance of Zones or Belts, it is ſomewhat doubtful if they are Clouds formed in *Jupiter*'s Atmoſphere, as Clouds are formed in ours, in which we obſerve no Conſtancy of Form, Poſition, or any Thing elſe.

Euphroſ. Well, but what are thoſe ſmall Stars I ſee by *Jupiter* — two on one Side and two on the other, at unequal Diſtances?

Cleon. They are the *Moons* or *Satellites* which give Light to *Jupiter* by Night, as our Moon does to us.

Euphroſ. Indeed! Do you ſuppoſe thoſe very ſmall Stars to be Moons as large as our Moon?

Cleon. Yes, my *Euphroſyne*, and larger by far; our Moon at that Diſtance would not be viſible through the beſt of Teleſcopes in uſe with us. Of theſe Moons thus Mr. *Brown*:

For ſignal Honour made, behold! afar
Four radiant Moons ſurround th' imperial Star,
(Large as our boaſted World) whoſe ſilver Light
Refreſh his Regions in the gloomy Night;
Nor this the Fancy of deluded Eyes,
Mark'd are their Periods thro' ſublimer Skies.
Oft does th' Aſtronomer his Tube diſplay
And view 'em in Eclipſe with pleas'd Survey.
To this the Curious their Diſcov'ry owe
Of Light's ſwift Motion, and its Meaſure know.

Euphroſ. Well, I do not envy *Jupiter* his four Moons, I believe he has Need enough of them. ——But how comes it to paſs, ſince *Mars* is ſituated between us and *Jupiter*, and we having one Moon and *Jupiter* four, that *Mars* has none at all?

Cleon. The Queſtion you ſtart very naturally offers, and is of ſome Importance, as it concerns the Analogy and Harmony of the ſeveral Parts of the great Machinery of our Syſtem. But you will excuſe me from a direct Anſwer 'till we come more immediately to conſider the Nature of *Moons* or *ſecondary Planets*, in another Converſation, particularly on that Subject.

Euphroſ. If you pleaſe, *Cleonicus*; —— but one Queſtion more —— If *Jupiter* be ſo very large a Planet, pray, what do you think of the Inhabitants there?

Cleon. 'Tis true, one can aſſert nothing poſitively of them, but if we reaſon from the Analogy of Things, they as much exceed us in Stature as *Jupiter*'s Globe exceeds ours in Diameter; and are therefore at leaſt ſixty Feet high; nor is there any Thing to be wondered at in this, ſince Things are *great and ſmall* only by Compariſon.

Euphroſ. I make no Doubt but this Planet made a notable Figure among the Deities of the heathen World in former Times.

Cleon. I need ſay only this, that he was adored with the greateſt Veneration under the Character of the *Moſt High and ſupreme Deity.*

Euphroſ. That is, I ſuppoſe, you mean the Heathens worſhipped the God and Creator of all Things, who is of himſelf inviſible, under the Shrine of this glorious Planet *Jupiter.*

Cleon. Yes, they did ſo; and made divers Statues and Images, inſomuch that almoſt every Nation had a *Jupiter* of their own, in Imagery. He was honoured with no leſs a Title than that of *The Father of the Gods and Men.*

Euphroſ. How came they originally by the Notion of *Jupiter*'s being the ſupreme Deity?

Cleon. Undoubtedly from the *Hebrew* People: For the ſupreme God among them being called *Jehovah*, or *Jovah* (as a late learned Biſhop ſays it was pronounced) the Heathens from thence, by an eaſy Derivation, had their Term *Jovis*, *Jove*, or *Jupiter*, which was the ſame Deity under different Names; according to the Addreſs of Mr. *Pope*'s Prayer,

> *Father of all in ev'ry Age,*
> *In every Clime ador'd;*
> *By Saint, by Savage, and by Sage,*
> Jehovah, Jove, *or* Lord.

That is to ſay; the *Hebrews* called him *Jehovah*; the Heathen, *Jove*; but the better informed *Chriſtians* call him *Lord* of the World.

Euphroſ. Pray, how did they ſet off their moſt high God in the *Pantheon?*

Cleon. He ſat on a *Throne* of *Ivory* and *Gold*, under a rich Canopy, with a Beard, holding *Thunder-bolts* in his Right-hand, and a *Sceptre* of *Cypreſs* in his Left, with an Eagle on the Top, and was inveſted with an *imbroidered Cloak* and *golden Shoes.*

Euphroſ. I ſuppoſe he was not a more ſplendid Star in the Heavens, than a ſacred and illuſtrious Theme among the Poets, too.

Cleon. 'Tis very true, he was not, as you will find by a few Citations from them; *Virgil* aſcribes a Sort of *Ubiquity* to him in theſe Words,

> *From the great Father of the Gods above*
> *My Muſe begins; for* all is full of *Jove.*
>
> Eclog. 3.

And in another Place thus:

The King of Gods and Men, whoſe awful Hand
Diſperſes Thunder on the Sea and Land,
Diſpoſing all with abſolute Command.

And again:

The mighty Thund'rer with majeſtic Awe
Then ſhook his Shield and dealt his Bolts around,
And ſcatter'd Tempeſts on the teeming Ground.

Homer aſcribes almoſt all the Attributes of Deity to *Jupiter* in theſe Verſes:

O Thou, whoſe Thunder rends the clouded Air,
Who in the Heav'n of Heav'ns has fix'd thy Throne,
Supreme of Gods! unbounded, and alone!

And in another Place,

So Jove *decrees, reſiſtleſs Lord of all!*
At whoſe Command whole Empires riſe or fall:
He ſhakes the feeble Pomp of human Truſt,
And Towns and Armies humbles into Duſt.

DIALOGUE XII.

Of the PLANET *SATURN.*

Cleonicus.

WELL, my *Euphroſyne*, the Order of our phyſical Speculations hath brought us at Length to the extreme Parts of the Solar Syſtem, I mean the *Orbit of Saturn*, which is the Boundary thereof, if we except the *Cometary Orbits.*

Euphroſ. I remember you told me, *Saturn* was the ſixth primary Planet, and the higheſt or moſt remote from the Sun.

Cleon. Yes.

Fartheſt and laſt, ſcarce warm'd by Phœbus' *Ray,*
Thro' his wide Orbit, Saturn *wheels away.*
How great the Change, could we be wafted there!
How ſlow the Seaſons! and how long the Year!

BAKER's Univerſe.

Euphroſ. I perceive from the *Copernican Syſtem*, that the Orbit of *Saturn* lies very far from the Sun, in Compariſon of the reſt, and, conſequently, that his Circuit is very large indeed.

Cleon. Yes, the Diſtance of *Saturn* from the Sun is computed to be no leſs than *Seven Hundred and Seventy-ſeven Millions of Miles*, which is 9½ times farther than the Earth; and therefore the *Light* and *Heat* at *Saturn* will be 90 times leſs than it is with us.

Euphroſ. Ninety times leſs! Why ſure they can neither *ſee* nor *feel* in *Saturn*. Well I thought *Jupiter* was cold enough to think on; but *Saturn* would freeze ones very Thoughts!

Cleon. They are inconceivably cold and dark there to be ſure; and this Speculation is the curious Theme of the following Verſes.

From hence how large, how ſtrong the Sun's bright Ball!
But ſeen from thence, how languid and how ſmall!
When the keen North *with all its Fury blows,*
Congeals the Floods, and forms the fleecy Snows,
'Tis Heat intenſe to what can there be known:
Warmer our Poles than is its burning Zone.
Who there inhabit muſt have other Powers,
Juices, and Veins, and Senſe, and Life than ours.
One Moment's Cold, like theirs, would pierce the Bone,
Frieze the Heart's Blood, and turn us all to Stone.

Univerſe.

Euphroſ. Dear Brother, forbear—you make me ſhiver to hear the cold Strains! can it be poſſible for any ſenſible Beings to endure that Intenſity of Cold, and live?

Cleon. Yes, undoubtedly; you ſee very ſmall and tender Animals endure the coldeſt Water in the Winter Time without any Concern. Yea, I have put thoſe little Creatures into a *freezing Mixture* made of *Nitre* and *Snow*, which is intenſely cold, and they ſeemed not affected with it. Yea, further; I have put theſe very ſmall Animals into a Tube of Water and froze them in a Cylinder of Ice for the Space of Half an Hour, and yet it has not killed them. You ſee therefore it is only a Conſtitution fitted to the Nature of the Element that is neceſſary to the enduring any Degree of Cold or Heat. As the ſame ingenious Author obſerves in the ſame Place:

Strange and amazing muſt the Diff'rence be
'Twixt this dull Planet and bright Mercury;
Yet Reaſon ſays, nor can we doubt at all,
Millions of Beings dwell on either Ball,
With Conſtitutions fitted for that Spot,
Where Providence, all-wiſe, has fix'd their Lot.

Euphroſ. Well, all the Works and Ways of Providence are wonderful; ſurely they who neglect or deſpiſe Philoſophy, muſt be ſottiſh Creatures indeed! they little know the Pleaſures that ariſe from its various and noble Speculations! But not to digreſs —— Pray, how long is the *Year* in *Saturn?*

Cleon. About the Length of 29½ of our Years; or more preciſely, it conſiſts of *Ten Thouſand Seven Hundred Fifty-nine Days and ſix Hours*; for in that Space of Time *Saturn* revolves once about the Sun. Of the *Saturnian* Year a Poet thus ſings,

View Saturn *laſt; how faint his diſtant Gleam,*
(Sublimeſt Planet in our Solar Scheme)
Tho' vaſt his Globe, ſo large his Orbit's Space,
Our Thirty Years *but ſhew his annual Race.*
Priz. Verſ. N°. III.

Euphroſ. Since his *Year* and *Seaſons* are ſo very long, how long may we ſuppoſe his *Days* and *Nights* to be?

Cleon. It is not yet known whether he turns upon his Axle or not, and therefore nothing certain can be ſaid of his Day or Night. But it is agreeable to the Nature of a Planet to turn on its Axis, and therefore he in all Probability does ſo, tho' we know it not.

Euphroſ. I am a little impatient to have a Sight of this Planet; they ſay there is a Kind of Ring which encompaſſes his Body, that makes this Planet a delightful and wondrous Spectacle.

Cleon. There is ſuch a Thing, and to the End that you may have a clear and perfect Sight of this ſingular and ſurpriſing *Phænomenon*, I have provided you a *reflecting Teleſcope*, which magnifies to a very great Degree, and is eaſily uſed when fixed on its proper Pedeſtal.

Euphroſ. I thank you, dear *Cleonicus*, for the Care you take to pleaſure me in this Reſpect; it is a curious Inſtrument indeed, and I doubt not but its Uſe is according.—Is it not yet dark enough to ſee the Planet?

Cleon. I believe it is nearly, or at leaſt will be by that Time the Tube is mounted.—I will look out—I ſee him plainly.

Euphroſ. Pray, ſhew him to me.

Cleon. You can't miſs ſeeing him; it is that pale bright Star you ſee towards the North-Eaſt, and is the biggeſt Star that now appears.

Euphroſ. I ſee the Star you mean—and long to view him thro' the Teleſcope; pray, fetch it out, *Cleonicus*.

Cleon. I will—here it is, and I'll fix it for your View;—it is done—look thro' it, my *Euphroſyne*, without touching it.

Euphroſ. I will—I ſee both the Planet and its Ring,—a moſt curious Sight, indeed!—he appears with a round Face, but not ſo big nor bright as *Jupiter*.—I ſee the Ring perfectly encircle his Globe—and extends on each Side to a conſiderable Diſtance.—I can alſo ſee the dark Space, on each Side, between the Planet and its Ring.—I alſo obſerve two or three ſmall Stars, which, I ſuppoſe, are his Moons, like thoſe I ſaw in *Jupiter*.—But he is moved quite off the Glaſs.

Cleon. I queſtion not but you are pleaſed with ſo uncommon a Sight. But this Inſtrument will make it as familiar as you pleaſe. You will obſerve, that he appears *Full-faced*, as indeed he always does, on Account of his prodigious Diſtance from the Sun in Compariſon of us; and alſo that he appears leſs than *Jupiter*, for ſo he, indeed, is by much.

Euphroſ. Pray, what is the Magnitude, or Bulk of *Saturn*?

Cleon. He is computed to be *Sixty-ſeven Thouſand Eight Hundred and Seventy Miles* in Diameter; and therefore he is in Bulk about *Six Hundred Times* bigger than our Earth; and a little more than half as big as *Jupiter.*

Euphroſ. But this *wonderful Ring* of his, what do you take it to be?

Cleon. The Learned abound with Conjectures about it; but as no Man can poſſibly know any Thing certainly of the Matter, I think it better to ſay Nothing; and chuſe rather to give you a poetical Deſcription of this extraordinary Phænomenon.

> *Muſe! raiſe thy Voice, myſterious Truth to ſing,*
> *How o'er the copious Orb a lucid Ring,*
> *Opake and broad, is ſeen its Arch to ſpread*
> *Round the big Globe at ſtated Periods led;*
> *Perhaps (its Uſe unknown) with gather'd Heat*
> *To aid the Regions of that gelid Seat,*
> *The Want of nearer* Phœbus *to ſupply,*
> *And warm with reflex Beams his Summer Sky;*
> *Elſe might the high plac'd World, expos'd to Froſt,*
> *Lie Waſte, in one eternal Winter loſt.*
>
> Prize Verſ. No. III.

Euphroſ. Do you know at what Diſtance this Ring is ſituated from the Body of *Saturn?*

Cleon. The Meaſures of Aſtronomers make it to be at the Diſtance of *Twenty-one Thouſand Miles* from *Saturn*, and alſo that its Breadth is equal thereto, or, as ſome ſay, its Breadth is *Twenty-nine Thouſand Miles.*

Euphroſ. Stupendious Magnitude! what can be the Meaning of it! what the Uſe? Say, *Cleonicus.*

Cleon. I can ſay after others, that it may poſſibly be appointed to give Supplies of *Light* and *Heat* to the Planet; but this Suppoſition, however plauſible, I do not think altogether reaſonable; for (1.) The Inhabitants have Conſtitutions ſuited to the Temperature of the Globe of *Saturn* undoubtedly, and therefore can't be ſaid to want more *Light* and *Heat*; our Degree of *Light* might blind them, and our Heat would make the Marrow fry out of their Bones, in all Likelihood. (2.) There are, as you ob-

obſerve, ſeveral Moons to make up the requiſite Degree of *Light*. And therefore the Uſe of that wond'rous Ring (tho' very great, to be ſure) may be to us entirely unknown.

Euphroſ. Well, I would not be over inquiſitive; 'tis a Pleaſure we know there's ſuch a Ring, be the Uſe of it what it will. But, pray, how many Moons hath *Saturn?*

Cleon. Thro' our common Teleſcopes we diſcover but *two* or *three*, tho' with the beſt Sort you may ſee *five*, of which I intend to give you a farther Account at another more convenient Time.

Euphroſ. I have no Occaſion to aſk concerning his *Conjunctions*, *Oppoſitions*, *Retrogradations*, *&c.* which I ſee, from the Plate, muſt follow from his being a ſuperior Planet, or having his orbit lying without that of the Earth, as in *Jupiter* and *Mars* you explained to me; and would only obſerve, that whether he be in Conjunction or Oppoſition, it appears to me that his apparent Magnitude can be but little varied, becauſe of the much ſmaller Diameter of the Earth's Orbit than its own.

Cleon. 'Tis well obſerved, Siſter; for there is but little Difference if view'd in the Oppoſition, when he is neareſt; or in the Conjunction, when he is fartheſt off.

Euphroſ. Did not the great Diſtance and long Period of *Saturn*'s Revolution occaſion him to be taken Notice of among the Heathens in ancient Times?

Cleon. As to his great Diſtance, they were far from being Aſtronomers good enough to know any Thing about that: But his ſlow Motion, and the great Length of his Year, occaſioned them to make him the *Emblem of Time*.

Euphroſ. In what Manner?

Cleon. They repreſented him as a decrepid, wrinkled old Man; with a long Beard, and hoary Head; round Shoulder'd, hollow Jaw'd, flat Noſed, hooked Chin'd, black Lips, and crooked Hands. In his Right Hand was a *ruſty Scythe*, and in his Left he held a *Serpent biting his Tail*; or, as ſome ſay, a Child, which he is about to devour.

Euphroſ. Why then he made but a Sort of contemptible Figure among Men in Days of old, I find; he was indeed a very fit *Symbol of Time*, which gives to every Thing a horrid Aſpect; or cuts down, and devours it; and that in an endleſs Circulation of Ages.—Pray, is there any Thing farther remarkable of *Saturn?*

Cleon. There are abundance of Things fabled of him, as you may meet with, and doubtleſs have, in many Books; but the moſt notable Thing of all is the Time in which he lived, called the *Golden Age.*

Euphroſ. I have read a Deſcription of that extraordinary Age in ſome Poet, but forget which.—I ſhould be glad to hear it repeated.

Cleon. Virgil gives a beautiful Deſcription thereof in his Eighth Book of *Æneid*; and *Ovid* in his Firſt Book of *Metamorphoſes.* Which, ſince it is agreeable to you, I ſhall rehearſe in Mr. *Dryden*'s Language.

The Golden Age *was firſt, when Man, yet new,*
No Rule but uncorrupted Reaſon knew;
And with a native Bent did Good purſue.
Unforc'd by Puniſhment, unaw'd by Fear,
His Words were ſimple, and his Soul ſincere:
Needleſs was written Law, where none oppreſs'd;
The Law of Man was written in his Breaſt.
No ſuppliant Crowds before the Judge appear'd;
No Court erected yet, nor Cauſe was heard;
But all was ſafe, for Conſcience was their Guard.
The Mountain Trees in diſtant Proſpect pleaſe,
E'er yet the Pine deſcended to the Seas;
E'er Sails were ſpread new Oceans to explore,
And happy Mortals, unconcern'd for more,
Confin'd their Wiſhes to their native Shore.
No Walls were yet, nor Fence, nor Moat, nor Mound,
Nor Drum was heard, nor Trumpet's angry Sound,
Nor Sword were forg'd: But void of Care and Crime,
The ſoft Creation ſlept away their Time;
The teeming Earth, yet guiltleſs of the Plough,
And unprovok'd, did fruitful Stores allow.
Content with Food which Nature freely bred,
On Wildings and on Strawberries they fed;
Cornels and Bramble-berries gave the reſt;
And falling Acorns furniſh'd out a Feaſt.

The Flow'rs, unſown, in Fields and Meadows reign'd,
And weſtern Winds immortal Spring maintain'd.
In following Years the bearded Corn enſu'd
From Earth unaſk'd, nor was the Earth renew'd:
From Veins of Vallies Milk and Nectar broke,
And Honey ſweated thro' the Pores of Oak.

DIALOGUE XIII.

On the Uſe of the GEOCENTRIC PLANETARIUM *by Means of an* Ephemeris.

Cleonicus.

WE have now finiſhed our Survey of the *Planetary Syſtem*, and I am well aſſured, my *Euphroſyne*, you underſtand the general Phænomena thereof very well; but ſomething yet remains to be underſtood upon this Head, and I am willing to hope will give you as much Pleaſure as any Part of our paſt Speculations, as it is of a practical Nature, and what you are to perform with your own Hands.

Euphroſ. I long to know what it is, *Cleonicus*, as every new Idea gives me new Delight.

Cleon. What I mean is what I ſometime ago hinted to you, *viz.* That it is not enough for you to know the ſpeculative Part of Aſtronomy, but alſo that you learn to find the Places and relative Aſpects of the Planets, from an EPHEMERIS, for every Day of the Year.

Euphroſ. And do you think I am capable of doing this, *Cleonicus?*

Cleon. Yes, what ſhould hinder you, when you are put into a proper Method for it?

Euphroſ. But I ſuppoſe I muſt firſt learn the Uſe of that Book, you call an *Ephemeris*.

Cleon. You muſt.—Here it is.—Look at it———

Euphroſ. It is but ſmall indeed, but it is filled with ſuch a Number of Characters, Figures, and Columns, that at firſt View I know not what to make of it.

Cleon. That is every One's Caſe in a new Attempt; when you conſider each Article of the *Ephemeris* ſeparately you will find it eaſy enough to underſtand.

Euphroſ. But firſt tell me why this little Book is called an *Ephemeris?*

Cleon. Becauſe it is a *Diary* or *daily Account* of the Motions or Places of the Planets, as they appear to the Eye placed both in the Sun, and at the Earth, throughout the Year.

Euphroſ. But why do you ſuppoſe the Eye to view the Planet from the *Sun,* ſince that is impoſſible?

Cleon. Becauſe on that Suppoſition you can obſerve or aſſign for any Time the *true Places* of the Planets in the Ecliptic; and this *true Place ſeen from the Sun,* is called the *Heliocentric Place* of the Planets, for the Name of the Sun in *Greek* is *Helios,* but if the Planets are view'd from the Earth (call'd in *Greek, Ge)* then their Places and Motions are called *Geocentric.*

Euphroſ. I underſtand you, I believe, pretty well; I ſee on the Right Hand Page, for every Month, a ſmall Table with the Title of *The Heliocentric Motions*; as there, on the Top, for the Month *December,* 1755.

The Heliocentric Motions.

Days	♄	♑	♃	♎	♂	♊	⊖	♊	♀	♐	☿	♋
1	29	26	4	22	24	33	9	3	29	6	18	40
6	29	35	4	45	27	0	14	8	7♑	0	16♌	51
11	29	45	5	8	29	27	19	13	14	54	11♍	7
16	29	54	5	30	1♋	53	24	18	22	48	1♎	47
21	00♒	3	5	53	4	17	29	24	0♒	42	19	41
26	00	12	6	16	6	40	4♋	30	8	36	5♏	38

Cleon. Very well, my *Euphroſyne.* You obſerve that Table divided in 7 Columns; in the firſt is placed every 5th Day of the Month beginning with the firſt. On the Top of each of the other Columns, the Character of the Planet and of the Sign in which it is on the firſt Day of the Month; and the Figures in the reſpective Columns ſhew the Place in *Degrees* and *Minutes* which the Planet is in, as ſeen from the Sun preciſely at 12 *o'Clock at Noon,* on the ſeveral Days in the 1ſt Column; for you muſt know, the *Aſtronomers always begin their Day at Noon.*

Euphroſ. This is all ſo plain, that I can't but apprehend it; and thus, for Inſtance, on *December* the 1ſt, at 12 o'Clock, I obſerved the *Heliocentric* Place of *Saturn* (♄) is in 29° : 26′ of *Capricorn* (♑); of *Jupiter* (♃) in 4° : 22′ of *Libra* (♎); of *Mars* (♂) 24° : 33′ of *Gemini* (♊); of the *Earth* (⊖) 9° : 3′ of *Gemini* (♊); of *Venus* (♀) in 29° : 6′ of *Sagittarius* (♐); and of *Mercury* (☿) in 18° : 40′ of *Cancer* (♋); and ſo for any other Day there ſpecified.

Cleon. Very right, my *Euphroſyne*, I ſee there will be no Difficulty about the other Table of the *Geocentric Motions*, where the Place of the Sun and each Planet is given in their proper Columns, as viewed from the Earth, for every Day at Noon.——

Euphroſ. But beſides theſe, there are ſeveral other Tables and Columns on the ſame Page; pray, what is their Uſe?

Cleon. We ſhall ſee that hereafter, Siſter; the *Heliocentric* and *Geocentric* Motion will be ſufficient at this Time to conſider; and becauſe we want to know conſtantly in what Part of the Ecliptic the Planets are, their *Geocentric Places* are ſhewn for every Day, as you ſee for the Month *December*.*

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* Tables of the *Heliocentric* and *Geocentric Motions* or *Places* for *December* 1755, are here added from *Parker*'s *Ephemeris*, leſt the Reader ſhould not have the ſaid Book at Hand; and one Month only is ſufficient for an Example of its Uſe.

TABLE

TABLE *of* GEOCENTRIC MOTIONS.

M D	☉	♐	☽	♏	♄	♑	♃	♎	♂ ℞	♋	♀	♐	☿ ℞	♏
1	9	3	9	51	25	21	13	0	17	39	17	33	23	53
2	10	4	25	3	25	26	13	10	17	30	18	48	23	44
3	11	5	10 ♐	21	25	32	13	20	17	20	20	4	23	32
4	12	6	25	33	25	38	13	29	17	9	21	19	23 D	44
5	13	7	10 ♑	29	25	44	13	38	16	57	22	34	23	55
6	14	8	24	59	25	50	13	47	16	44	23	50	24	19
☉	15	9	9 ♒	0	25	55	13	05	16	30	25	5	24	52
8	16	10	22	30	26	1	14	6	16	15	26	20	25	32
9	17	11	5 ♓	32	26	7	14	14	15	59	27	36	26	17
10	18	12	18	9	26	14	14	23	15	43	28	51	27	8
11	19	13	0 ♈	27	26	20	14	31	15	26	0 ♑	6	28	2
12	20	14	12	32	26	26	14	40	15	9	1	22	29	1
13	21	15	24	28	26	32	14	48	14	51	2	37	0 ♐	4
☉	22	16	6 ♉	19	26	39	14	57	14	32	3	52	1	11
15	23	17	18	9	26	45	15	5	14	12	5	8	2	22
16	24	18	0 ♊	1	26	51	15	13	13	52	6	23	3	37
17	25	19	11	58	26	58	15	21	13	31	7	38	4	53
18	26	21	24	0	27	4	15	29	13	10	8	53	6	10
19	27	22	6 ♋	10	27	11	15	36	12	49	10	8	7	28
20	28	23	18	27	27	17	15	44	12	27	11	24	8	47
☉	29	24	0 ♌	53	27	24	15	51	12	5	12	39	10	6
22	♑	25	13	29	27	30	15	58	11	42	13	54	11	28
23	1	26	26	17	27	37	16	5	11	19	15	10	12	50
24	2	27	9 ♍	17	27	44	16	12	10	55	16	25	14	15
25	3	29	22	33	27	50	16	18	10	32	17	40	15	41
26	4	30	6 ♎	7	27	57	16	25	10	8	18	56	17	9
27	5	31	20	1	28	4	16	31	9	44	20	11	18	36
☉	6	32	4 ♏	15	28	10	16	37	9	20	21	26	20	4
29	7	33	18	50	28	17	16	43	8	57	22	41	21	32
30	8	35	3 ♐	39	28	24	16	50	8	33	23	57	23	1
31	9	36	18	38	28	31	16	56	8	9	25	12	24	28

Euphroſ. Well, let us not ſpend Time about Things ſo eaſy; I ſee that for every Day of the Month, the Places of the Sun and all the Planets are ſhewn in the Ecliptic, as they appear from the Earth; but pray, what depends on all this?

Cleon. A very pleaſant *Aſtronomical Praxis*; by which you may at any Time be able to entertain yourſelf in a moſt rational and agreeable Manner, that is to ſay, you may in a Minute or

two,

THE GEOCENTRIC PLANETARIUM.

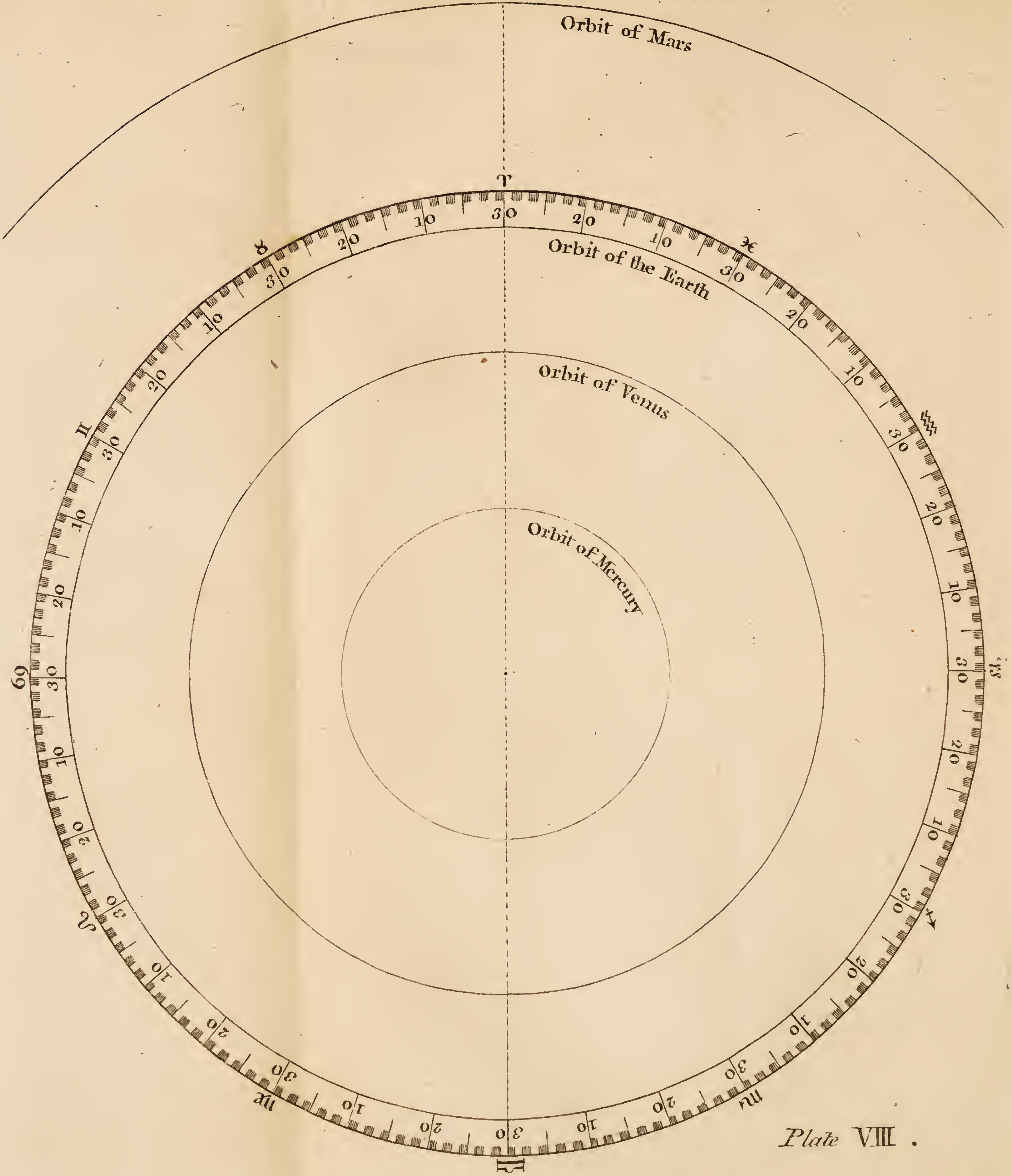
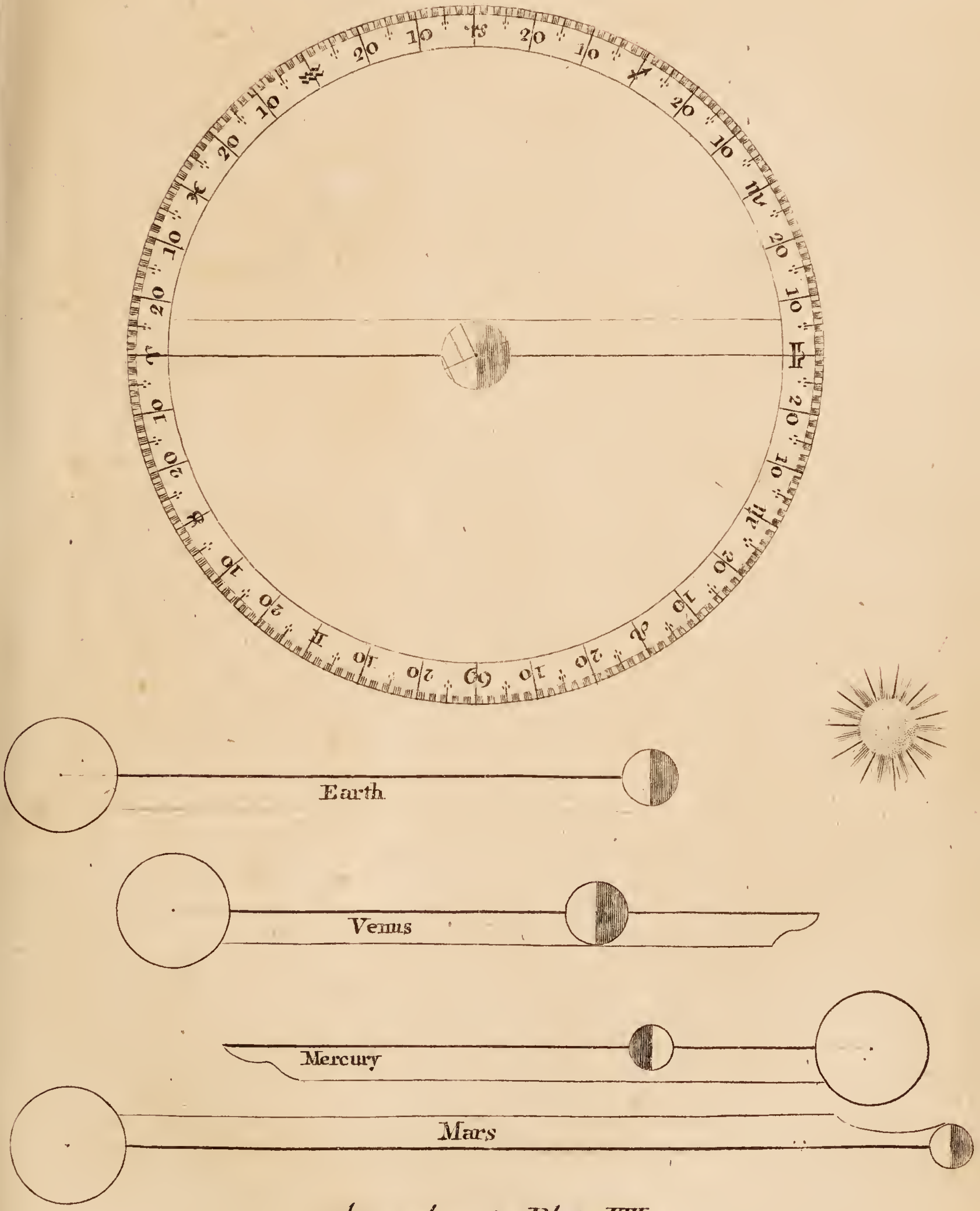
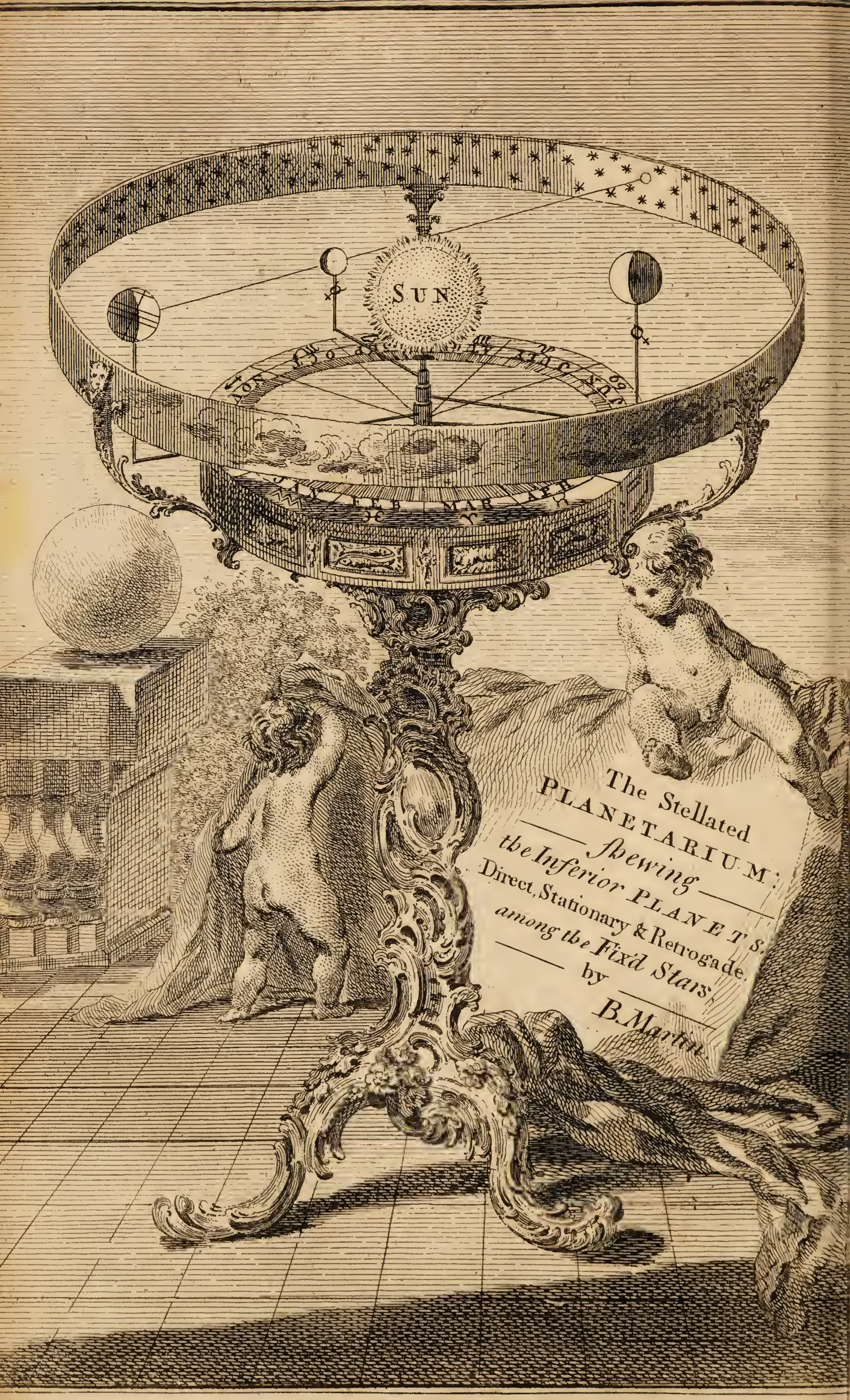


Plate VIII.



Appendage to Plate VIII.

Plate IX.


SUN
JAN
FEB
MAR
APR
The Stellated
PLANETARIUM:
ſhewing
the Inferior PLANETS
Direct, Stationary & Retrogade,
among the Fix'd Stars,
by
B. Martin.

two, repreſent to your Self the true Appearance of the planetary Syſtem, juſt as it really is, in the Heavens for any Day you pleaſe; by aſſigning to every Planet its proper Place in its Orbit.

Euphroſ. This will be doing great Things indeed, *Cleonicus*; but how am I to go about it? I long to know ———

Cleon. For this Purpoſe, my *Euphroſyne*, I have prepared for you what I ſhall call a GEOCENTRIC PLANETARIUM, which you here ſee on this large Sheet of Paſtboard, where you obſerve the Orbits of all the Planets are drawn at their proper Diſtances from the central Sun, in the ſame Proportion as in the Syſtem itſelf; and in the next Place, you ſee the Planets themſelves all *moveable* in their Orbits, on *paper Labels*, about the Center of the Sun. Next, you ſee the Orbit of the Earth divided into its 12 Signs and Degrees, which we ſhall call the *Solar Ecliptic*; in this, the *True* or *Heliocentric Places* of the Planets are eſtimated. And, in the laſt Place, about the Earth you ſee a ſmaller Circle of the Signs, moveable about its Center, in which the Planets viewed from the Earth, muſt all appear, and which for that Reaſon I ſhall call the *Geocentric Ecliptic.**

Euphroſ.

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* I have added this Plate, with its Appendix, that ſuch Gentlemen and Ladies as have not the Opportunity of a *real Planetarium*, may in a great Meaſure ſupply the Want of it by this *Geocentric Planetarium*, eſpecially as ſomething of this Kind has been always wanting to give Youth a Taſte of the Pleaſure of *practical Aſtronomy*.

In order then to prepare this Inſtrument for Uſe, you proceed in the following eaſy Method.

1. Cut the eighth Plate out of the Book, and paſt it on a Sheet of *Card Paſt-Board.*

2. Then with a Pair of drawing Compaſſes, make the Orbit of *Mars* a compleat Circle on the Paſt-board. Then cut out the Whole, of a circular Form, a little beyond the Orbit of *Mars.*

3. In the Appendix to this Plate, there are engraved the Labels of *Mercury*, *Venus*, the *Earth*, and *Mars*, which are to be cut out cloſe to the black Lines; theſe, together with the Face of the Sun, are to be placed on the Center of the Planetarium on a String, by which they may be tied cloſe down, yet freely moveable about the Center, ſo that the Center of the Planet on the Label may be always in the Orbit. Note, the Label of the Earth muſt be uppermoſt, and the Face of the Sun on that.

4. Cut out the *Geocentric Ecliptic*, ſo that it may conſiſt only of the Circle of the Signs, and the Diameter between the black Lines; and let the Center of this be placed on a Thread through the Center of the Earth

Euphroſ. So far I underſtand you; but I fear leſt what is to come ſhould prove a much greater Trial of Skill.——

Cleon. There is no Grounds of Fear to you, Siſter; if you attend to the following Precepts, every Thing will be eaſy.

Firſt, obſerve in the Ephemeris the Heliocentric Place of each Planet, and bring the Label of the Planet to that Sign and Degree in the *Heliocentric Ecliptic*, that is, ſo that the Line which paſſes through the Center of the Planet may cut that Degree.

Secondly, Having done this for every Planet, fix them down to their proper Places in their Orbits by a *ſmall Pin* through their Centers.

Thirdly, Bring the Earth to its Heliocentric Place, and fix the Label by a Pin paſſed through it into the Board.

Fourthly, The Geocentric Ecliptic is then to be moved about the Earth, and placed in ſuch a Manner, that the Line of ♈ ♎ paſſing through the Earth's Center, may be parallel to or equally diſtant from the ſame Line of ♈ ♎ in the Solar Ecliptic, which you may eaſily do by the Eye.

Fifthly, This Geocentric Ecliptic ſo rectified, is to be fixed by a Pin through that Part of it which lies remote from the Sun.

Sixthly, Then in the laſt Place, ſtrain a Thread over the Center of the Earth and each reſpective Planet, and that will cut the *Geocentric Ecliptic* in that Point where the Planet will appear to an Eye at the Earth. And thus, with a little Practice, you will be able immediately to exhibit the Syſtem of Planets, both as it is in it's Self, and as it appears to us at any Time.

Euphroſ. I make no Doubt but I ſhall underſtand theſe Precepts very well, when I join with them the Practice, in which you will aſſiſt me a little at firſt.

Cleon.

Earth on the Label, and tied down on it, ſo that it may freely move about the Earth's Center. Then is it fit to be uſed, as in the Dialogue above is directed.

5. To fit this Inſtrument for *Jupiter* and *Saturn*, it muſt be ſtuck on to the Side of a Room, or on a large round Table; you muſt then lay a Thread over the Center of the Sun, and *Jupiter*'s Place in the Ecliptic about the Sun, and at 12 ½ Inches from the Center, ſtick a Patch, and it will be the true Place of *Jupiter*. For *Saturn* you do the ſame, but for him you muſt place the Patch at the Diſtance of 23 ¾ Inches. And indeed, in this Manner, Patches may be placed on the Orbit of the other Planets, if the Trouble of the Labels be thought too much.

Cleon. That I ſhall do in the next Place; therefore, to begin, take the Ephemeris and look in the Heliocentric Table for the Places of the Planets for the 26th Day of *December* next, and let me hear you ſay what they are for each Planet.

Euphroſ. I will —— let me ſee, the Planet *Mercury* ☿ is in 5° : 38′ of *Scorpio*, (♏) and therefore, I ſuppoſe, I muſt take this Label of *Mercury* and bring the Edge of it to that Point of the Solar Ecliptic.—Well, here I fix it with a Pin, and what next, *Cleonicus?*

Cleon. You muſt now proceed to do the ſame with all the Reſt; pray, where do you find the Planet *Venus* ♀ ?

Euphroſ. I find her Place to be in 8° : 36′ of *Aquarius* ♒, to which I bring her Ladyſhip, and pin her faſt down. The next I muſt look for is the Earth—I ſee it—we are that Day in 4° : 30′ of *Cancer* ♋; thither I bring the Earth's Label, and fix it down with a Pin—ſo far I preſume I am right, *Cleonicus?*

Cleon. You proceed very well; do the ſame by all the Reſt, and you will erect a much better Scheme of the Heavens than any Aſtrologer could ever yet pretend to.

Euphroſ. The Place of *Mars* ♂ I ſee is in 6° : 40′ of *Cancer* ♋;—*Jupiter* ♃ is in 6° : 16′ of *Libra* ♎;—and *Saturn* ♄ is in 0° : 12′ of *Aquarius* ♒.—To theſe Places I have brought, and pinned down their Labels—And now, what Remains?

Cleon. Only to rectify the *Geocentric Ecliptic* ——

Euphroſ. I know what you mean,—it is to place the Ecliptic about the Earth in a parallel Situation to that about the Sun—ſee, there it is done.

Cleon. With great Pleaſure I ſee how readily you do it; you have now nothing more to do, but to lay a Thread from the Center of the Earth over the Centers of the ſeveral Planets; and you will then obſerve the Places in which they ſeverally appear in the *Geocentric Ecliptic* are the ſame very nearly as thoſe you ſee in the other Table for the *Geocentric Motions*.

Euphroſ. Indeed! that will give me great Pleaſure—I'll try—I lay the Thread from the Earth over *Mercury*, and find it cuts the *Geocentric Ecliptic* in the 17° of ♐ *Sagittarius* —— Now let me ſee the Table,—*Mercury*'s Place is there 17° : 9′ of the ſame Sign.—I think I am very near the Matter, *Cleonicus*.

Cleon. As near as you can deſire or expect to be; for in *Inſtrumental Aſtronomy*, we muſt not ſtand for a few Minutes. Well, and where do you find *Venus*, my *Euphroſyne?*

Euphroſ. I will tell you preſently — I lay the Thread tight over *Venus*, and it cuts the Geocentric Ecliptic in 18° $\frac{1}{2}$ of ♑ *Capricorn*—Now to the Table — Her Place is there 18° : 56′— How! that is almoſt 19°—ſure I am a little out here———

Cleon. Not at all, Siſter; for unleſs the Degrees were very large, it is no Wonder if you miſtake $\frac{1}{4}$ or $\frac{1}{2}$ a Degree now and then, it is enough, if by Inſtruments we come but nigh the Mark.

Euphroſ. Well, next for *Mars*—the String laid over that Planet cuts the Ecliptic in 10° of ♋——in the Table I ſee it is 10° : 8′——pretty near.——I next extend the String to *Jupiter*'s Center, and it cuts——let me ſee——15° $\frac{1}{2}$ of ♎;—— in the Table, that Planet ſeen from the Earth, is in 16° : 25′ of ♎ —— I am near the Truth here alſo.——In the laſt Place, let me try for yonder Planet *Saturn* —— I lay the Thread over his Center, and it cuts the Ecliptic in 28° of ♑;——in the Table it is 27° : 57′, within 3′ of the Truth.

Cleon. By this *Praxis*, you ſee, my *Euphroſyne*, how nearly the Inſtrument and the Table agree; and how eaſy it is in this Manner to repreſent the Situations and Aſpects of the Planets for any other Time. The Reverſe of this Proceſs is alſo very eaſy, *viz.* to find the Heliocentric or true Places of the ſeveral Planets in their reſpective Orbits, by laying a Thread from the Earth's Center to their apparent or Geocentric Places; for the Thread ſo extended will always cut the Orbit of the Planet in the Place where it really is at that Time.

Euphroſ. It is much eaſier than I thought it was, and will often be the ſubject of my leiſure Hours Amuſement.—But as you mentioned the *Aſpects* of the Planets, I ſhould be glad to know what is meant by the *Lunar Aſpects*, and *Aſpects* at the *Earth*, in a Table for every Day under the Heliocentric Motions.

Cleon. Thoſe Tables of Aſpects are of no great Importance; they only ſhew us how the Planets are poſited with Reſpect to the Moon in one Table, and with Reſpect to each other, as ſeen from the Earth, in the other. And they uſe the Symbol △ for the *Trine Aſpect*, that is, when the Planets are a third Part of the Ecliptic diſtant from one another, *viz.* 4 Signs; if they are but 3 *Signs* apart, that Aſpect is called *Quartile*, denoted by □; if but 2 *Signs* from each other, it is called a Sextile, and is ſhewn by this Mark *; if they are in *Conjunction*, it is ſhewn by ☌, and if in Oppoſition by ☍. And the Number placed by the Symbol, ſhews the Hour after Noon, when that Aſpect happens.

Euphroſ. I believe I underſtand all that you have ſaid, *Cleonicus*; but let me try if I can make it out by Experiment.

	The Lunar Aſpects.						Aſpects at the Earth.
	☉	♄	♃	♂	♀	☿	
1				△ 11		☌ 22	
2		* 0					☽ Perig.
3	☌ 1		* 5		☌ 17		
4							
5			□ 6	☍ 11		* 23	
6		☌ 1					* ☉ ♃
☉	* 11		△ 9				
8					* 8	□ 6	
9				△ 20			* ♄ ☿
10	□ 0	* 16			□ 28	△ 18	
11							
12	△ 6		☍ 5	□ 6			
13		□			△ 18		□ ♃ ♂
☉				* 18			
15		△ 18					
16						☍ 8	☽ Apog.
17			△ 6				
18	☍ 5						
19			□ 18	☌ 13	☍ 8		
20		☍ 18					
☉						△ 18	☍ ♂ ♀
22			* 6				
23	△ 10						
24				* 3	△ 13	□ 9	
25	□ 21	△ 11					* ♃ ☿
26			☌ 18	□ 7		* 19	
27		□ 14			□ 0		
☉	* 4			△ 10			
29		* 5			* 7		
30			* 21				☽ Perig. ☍ ☉ ♂
31						☌ 10	

I obſerve againſt the 26th of *December* (to uſe the ſame Example as before) in the Column under *Jupiter* ♃ there is placed ☌ 18, which I apprehend denotes the Planet is in *Conjunction with the Moon* at 18 Hours after Noon—But now, as there are but 12 Hours from Noon to *Midnight*, pray, what am I to underſtand by the 18th Hour, *Cleonicus?*

Cleon. Why you are to reckon 18 Hours from Noon of the 26th; 12 of which will bring you to Midnight, and the other 6 will make 6 o'Clock in the Morning of the following Day; ſo that the Conjunction happens on the 27th of *December* at 6 in the Morning.

Euphroſ. Poh, that I could not think on ſo eaſy a Thing as that—well, what is the next *Lunar Aſpect* that I ſee againſt the ſame Day—it is □ 7, in the Column of ♂, by which I ſee *Mars* will be in its *Quartile Aſpect* with the Moon, or 4 Signs from her, at 7 o'Clock that Night—Again: I ſee in the Column of ☿, the Aſpect ⚹ 19, ſhewing *Mercury* to be in *Sextile* with the Moon, at—let me think—19 is equal to 12 and 7—Oh, at 7 o'Clock the next Day.

Cleon. Very right; one Example more of the *Aſpects at the Earth* will make you a perfect Miſtreſs of this Part of the Science of the Stars.

Euphroſ. That gives me no Trouble; for againſt the 25th Day, I ſee the Characters ⚹ ♃ ☿, which ſhew that *Jupiter* ♃ and *Mercury* ☿ ſeen from the Earth, have a Sextile Aſpect ⚹, or are two Signs diſtant from each other.

Cleon. Very well; and this you ſee confirmed by the *Geocentric Planetarium*, and alſo by the Table of Geocentric Motions, for the Place of ♃ is there 26° : 18′ of *Libra* ♎, and the Place of *Mercury* is 15° : 41′ of ♐ *Sagittarius*, which is near 2 Signs or 60 Degrees from the other. And as you are now ready in the Uſe of the *Ephemeris*, and can find the Places and Aſpects of the Planets for any given Day, as they are ſeen, both from the Sun and Earth, we may proceed to the Uſe of the *Stellated Planetarium*, which is ſomewhat different from what you have yet ſeen, and this ſhall be the Subject of the next Converſation.

DIALOGUE XIV.

On the Uſe of the STELLATED PLANETARIUM.

Euphroſyne.

SINCE I laſt ſaw the *Planetarium*, I obſerve you have made an Addition to it; pray, what means that Hoop about it, with ſo many ſmall Stars?

Cleon. That is to anſwer the Purpoſe I have often mentioned to you, of ſhewing more plainly and directly the Manner in which the Planets muſt neceſſarily appear to us to go *forwards and backwards*, and at Times be Stationary, among the Stars in that Part of the Heavens thro' which they paſs; which Stars are thoſe engraved on the Hoop, and this *ſtellated Zone* will therefore fitly repreſent the *artificial* ZODIAC *of the Planets*.

Euphroſ. You have indeed often promiſed me the Pleaſure of thoſe Appearances in this Way, which I preſume will be more natural than thoſe in which I have already viewed them. But I obſerve, you have only the three Planets next the Sun, in the Planetarium now.

Cleon. They will be ſufficient for the preſent; and you will take Notice that the *Wire* which paſſes from the Earth thro' the Planet *Mercury* to the *ſtarry Zodiac*, does repreſent a *Ray of Light*, by which the Planet is ſeen by the Eye; and as the Planet moves on the Inſtrument it will point out the apparent Place of the Planet among the Stars, juſt as a Ray of Light ſhews the apparent Place of the real Planet in the Heavens.

Euphroſ. I ſee the Congruity of ſuch a Repreſentation; and I farther obſerve, you have placed theſe three Planets at their proper or proportional Diſtances from the Center of the Sun.

Cleon. I have placed them at their true Diſtances that you may ſee the Times employed in their *direct and retrograde Motions*, and their *ſtationary Aſpects* are the very ſame in the Planetarium as in the Heavens, or in the *Ephemeris*, where the ſaid Motions are all minuted down very punctually.

Euphroſ. I ſhall be pleaſed with repeating this *aſtronomical Praxis* in a different Way from that of the *Geocentric Planetarium*, though that delighted me much; eſpecially as I apprehend this will be more natural, and perfect: But as the *Ephemeris* will be neceſſary I will go and fetch it——Here it is, *Cleonicus*, how are we to proceed with it?

Cleon. I will tell you——give me the Book——let us now propoſe to find when the Planet *Mercury* next begins to appear *direct* in Motion, when *ſtationary*, and when *retrograde*; and how long a Time each of theſe *Phænomena* will take up.

Euphroſ. This will be very entertaining; but, pray, will it not be required to find the true Places of the Earth and the Planet for this Purpoſe?

Cleon. It will, and that you can eaſily do for any given Time; now the Time when every Planet begins to appear direct in Motion, is marked with the Letter D, and when *retrograde*, with the Letter ℞; and therefore may be eaſily obſerved at any Time, and ſhewed by the *Stellated Planetarium.*

Euphroſ. Well, I long to try the little Skill I have in a Solution of this Problem. The Planet *Mercury* I ſee you propoſe for the Subject, but which *Ephemeris* muſt I uſe for this Purpoſe, this for the old Year 1755, or muſt we have one for the preſent new Year 1756?

Cleon. It will be beſt to make uſe of both, becauſe the Planet *Mercury* begins to be *direct* in Motion the 4th Day of *December* 1755, as there you ſee in the Table, in the Column for *Mercury.*

Euphroſ. I do——I ſee the Letter D placed there, to denote it—It is then in the 23° 44′ of *Scorpio* ♏, ſeen from the Earth.

Cleon. Very good, my *Euphroſyne.* Now let us place the Earth upon its proper Stem or Arm, and juſt over the 24th Day of *December*, 1755; and you obſerve a fine long moveable Wire in the middle Part of its Surface.——

Euphroſ. I do.——But what Purpoſe is that Wire to anſwer?

Cleon. It will paſs through the Body of the Planet *Mercury*, when placed on its Arm, and its End will conſtantly paſs by and among the fixed Stars on the Hoop or *Zodiac*; and ſo it will repreſent the *Ray of Light*, by which the Planet is ſeen by us, and by which its *apparent Motions* will be determined and ſhewn among the Stars in the Heavens juſt as they appear to us.

Euphroſ. Well, I long to ſee the Machine in Motion.—— But do you not place the Planet *Mercury* alſo in that Part of the Ecliptic, which it really poſſeſſes at that Time?

Cleon. Yes, or elſe we do Nothing: But in order to do that rightly, you will obſerve, that in the Table of *Heliocentric Motions* (Page 86) the Planet's Place for the firſt Day was in 18° 40′ of ♋, and on the 6th Day in 16° 51′ of *Leo* ♌; therefore in five Days the Planet moved 28° 11′; one fifth Part of which is 5° 40′, the Motion in one Day; in two Days therefore it moved thro' 11° 20′, which ſubducted from 16° 51′ leaves 5° 31′ of *Leo* ♌, for its Place on *December* the 4th, 1755, when it began to be *direct* in Motion; and of Courſe to that Part of the Ecliptic the Arm which carries *Mercury* muſt be ſet, which you ſee I have done. ——— Next I paſs the Wire thro' the Body of *Mercury* —— and then I place the Planet on its Stem —— laſtly, I fix a ſmall, white, ſhining Bead on the End of the Wire by the Stars. —— And thus the *Planetarium* is rectified for our Purpoſe. ——— You now obſerve the *Earth*, *Mercury* and *Venus* all in Motion.

Euphroſ. I do; the Planet *Mercury* goes the ſame Way with the Earth, from Weſt to Eaſt —— The white *Bead* alſo moves among the Stars the ſame Way.

Cleon. Very well, Siſter; and you will ſee the *Planet*, and its *repreſentative Bead* both keep moving the ſame Way for a conſiderable Time. —— You will obſerve it thro' all the preſent Month *December*. ——— Let us now take the new *Ephemeris* for the Year 1756, and you will ſee the *Bead* keep moving on the ſame Way thro' all *January*. —— Now take the Book, and as there will be Time enough, let me ſee you find the Day when the Planet begins to be *Retrograde*.

Euphroſ. I ſhall ſee that ſoon — let me look in *February* — I ſee no Letter ℞ there — Next, let me look at *March* — Oh, there I have it, againſt the 2d Day I ſee the Letter ℞ of *Retrogradation*. —— Hence I obſerve the Planet is direct in Motion from *December* 4, 1755, to *February* 2, 1756.

Cleon. Admirably good, Siſter; and now attend to the Planet in the Machine. —— The Earth and the two Planets ſtill keep moving forward;—but *Mercury*'s Repreſentative among the

Stars begins to ſlacken its Motion — do you not obſerve a ſenſible Difference between it and the Planet itſelf, my *Euphroſyne?*

Euphroſ. Yes, indeed, I do; and it is very pretty and pleaſant to behold it. ——— Let me look, what Day the Earth is upon — The 11th of *February* — very well; now let me ſee the new Year's *Ephemeris* —— How much do I find it there move from the 11th to the 12th? — about 2 ½ Degrees, and that is not half ſo faſt as its true Motion —— it now moves ſlower, — now very ſlow indeed — not one Degree in a Day, — it is now the 23d of *February*; ——— It ſcarcely now moves at all —— there it is quite at Reſt ——— the Earth is now upon *March* the 1ſt; —— Well, and in the *Ephemeris*, *March* the 2d ſhews it begins to be *retrograde* by the Mark ℞. ——— All this is wonderfully natural, inſtructive, and entertaining, beyond any Thing of this Sort that I have ſeen before.

Cleon. It is not ſtrange the Phænomenon this Way ſhewn ſhould pleaſe you ſo much; becauſe it is ſo natural as to be the very Thing itſelf. You'll ſee by the *Ephemeris*, that the Planet is really not *Stationary* at all, but only in Appearance; and that as ſoon as the Bead ceaſes to move forwards, it begins to move backwards.

Euphroſ. I do; for I obſerve that from *February* 29 to *March* the 1ſt, it moved two Minutes of a Degree forwards, but from the 1ſt to the 2d of *March*, it moved 6 Minutes back again. — Whence I learn that the Planets are (as you ſay) *ſtationary* only in Appearance, and that ariſing from the Motion being inſenſibly ſlow a few Days only. ——— But behold, it is now going backwards —— Good Heavens, how faſt it moves! —— 'twill not be long e'er it gets quite back again. ——— How very ſwift the Motion, and ſhort the Time of its Retrogradation ——— Why, before the Month is out, it ſtops again —— it moves no longer. ——— The Earth is now at *March* the 25th —— The Letter D is there too, in the *Ephemeris* ——— How exact is the Agreement between the *Book*, the *Planetarium*, and the *Syſtem* itſelf? ——— The ſame Things appear in all, and force themſelves upon the Underſtanding, at the ſame Time they fill the Mind with the moſt ſublime and rational Pleaſures.

Cleon. The *retrograde Motion* in *Mercury* is but of ſhort Duration indeed, as in the preſent Caſe no more than 23 Days;

whereas he continues *direct* in Motion about 90 Days, which is more than three Times as long. And in the ſame Manner we might ſhew the direct and retrograde Motions of *Venus*, or any of the other Planets; for the ſuperior Planets, *Mars*, *Jupiter* and *Saturn*, may be placed on this *Stellated Planetarium* in their true Proportion of Diſtances, and then the Times of their appearing direct and retrograde among the Stars on the Inſtrument, will be the ſame to a Day as we obſerve them in the Heavens. But we muſt at preſent deſiſt from a farther Speculation of the *Planets*, and leave what remains till you are a little more prepared for *aſtronomical Calculations*, and the Uſe of Tables for that Purpoſe.

DIALOGUE XV.

Of the COMETS.

Euphroſyne.

YOU have, dear *Cleonicus*, obliged me with a long and particular Account of the ſix *primary Planets*, as they are called, which conſtitute the moſt conſiderable Part of the Solar Syſtem. But what ſucceeds to theſe? When we are arrived to the out-moſt Bounds of the Syſtem, where go we then?

Cleon. Where go we! much farther, my *Euphroſyne*, than we have yet been.

Euphroſ. What, to the Stars, I ſuppoſe.

Cleon. No, no; now you over ſhoot the Mark; we muſt take a much longer Time to travel thither.

Euphroſ. It can't be the Moon, for we left her far behind, hovering about the Earth. But hold—I recollect—'tis the Comets we next ſurvey; did you not intimate thus, *Cleonicus*? when we laſt converſed together.

Cleon. Yes, I did; the Comets next preſent themſelves as the Subject of our Speculation.

Euphroſ. Pray, what is a Comet?

Cleon. A Comet is what the common People call a *Blazing Star*, becauſe it appears like a large Star with a long Tail, *blazing* as it were, or ſtreaming from it. It is a very extraordinary and amazing Sight, and is thus finely deſcribed by Mr. *Baker*.

At his Command, affrighting human Kind,
Comets drag on their blazing Lengths behind:
Nor, as we think, do they at Random rove,
But in determin'd Times, thro' long Ellipſes move;
And tho' ſometimes they near approach the Sun,
Sometimes beyond our Syſtem's Orbit run,
Throughout their Race they act their Maker's Will,
His Power declare, his Purpoſes fulfil.

Thus alſo *Virgil:*

The threat'ning Comets, when by Night they riſe,
Shoot ſanguine Streams and ſadden all the Skies.

Euphroſ. Did you ever ſee a Comet, *Cleonicus?*

Cleon. Yes; but they very rarely appear; and tho' they are many in Number, yet their long Periods render their Return but ſeldom, and therefore a Comet can't be often ſeen.

Euphroſ. How long is it ſince the laſt Comet appeared?

Cleon. The laſt we ſaw here in *England*, was in the Winter of the Year 1743, but mention is made by Foreigners of others appearing ſo late as 1748.

Euphroſ. You ſay the Comets are many in Number, pray, can you tell how many?

Cleon. No; all thoſe which have been duly obſerved, and fallen under the Notice of Aſtronomers, are about 39; tho' 'tis poſſible, if not probable, there are, belonging to this Syſtem, many more.

Euphroſ. But I want to know what a Comet is, or what it is that makes the Appearance of a Star and its blazing Tail?

Cleon. They are ſuppoſed to conſiſt of a very ſolid, compact and durable Subſtance, capable of the greateſt Degree of Heat and Cold without Diſſolution; and of an opake Nature, ſhining only by Reflection of the Sun Beams, like other Planets.

Euphroſ. By that you intimate the Comets to be a Kind of Planets.

Cleon. They are moſt certainly ſo; for they move in ſtated Periods of Time about the Sun; of which Periods, ſome are longer, ſome ſhorter, as in the other Planets.

Euphroſ. Are the Times of the Periods of theſe Cometary Planets known by Aſtronomers, like thoſe of the other?

Cleon. No, but of ſome few only; as that which appeared in 1680 hath its Period in 575 Years; that in 1661, has its Period in 129 Years; and that of 1682 has its Period the ſhorteſt of all, *viz.* 75 $\frac{1}{2}$ Years. So that the ſhorteſt Period of the Comets is much longer than the longeſt Period of the Planets.

Euphroſ. Well, but if this laſt Comet's Period be but 75 $\frac{1}{2}$ Years, and he appeared in the Year 1682, it muſt be expected that he will again appear in the Year 1758; What ſay you, *Cleonicus?*

Cleon. Say, 'tis true, it will undoubtedly then appear, to the great Pleaſure and Surprize of all the curious Part of Mankind.

Euphroſ. I hope, as the Time is ſo near, we ſhall both live to ſee ſo extraordinary a Phænomenon.

Cleon. I hope ſo too; I ſhould ſcarce regret Death ſo much on any worldly Account as preventing me of ſo deſirable a Sight.

Euphroſ. In what Kind of Orbits do the Comets move about the Sun?

Cleon. In ſuch as are of an *oval* or *elliptical* Form, like that of which you ſaw a Part in the Plate of the ſolar Syſtem.

Euphroſ. Here is the Plate you mention, —— I ſee the Orbit and the Comet in it: The Sun is very near to one End of it, I ſee, and the two Sides of the Orbit of the Comet runs out far beyond the Planetary Syſtem.

Cleon. Yes, and ſo it is in Truth; the Comets in one Part of their Orbits approach extremely near the Sun; and in another, are immenſely diſtant from him. In ſhort, they come nearer to, and go farther from the Sun, than any of the Planets by much.

Euphroſ. Why then they muſt needs be ſometimes much *hotter than Mercury*; and at other Times much *colder than Saturn*;

turn; for I preſume, they have no Heat but what they receive from the Sun.

Cleon. They have not; and therefore they have the greateſt Extremities of Heat and Cold by Turns; for when they are in that Part of their Orbit neareſt the Sun, they conceive a prodigious Degree of Heat, which gradually diminiſhes as they receed from the Sun, and till becoming cold, that Coldneſs gradually increaſes to an Extremity proportional to the Diſtance they go from the Sun?

Euphroſ. Pray, can Aſtronomers tell the neareſt and greateſt Diſtance of Comets from the Sun?

Cleon. Of ſome few they can pretty nearly; particularly that Comet in 1680 came ſo near the Sun, that it was not a ſixth Part of the Sun's Diameter diſtant from his Surface; and therefore, its Heat muſt then be *two thouſand Times hotter than red hot Iron.* And from thence it took its Courſe from the Sun to the Diſtance of above 11 *Thouſand Millions of Miles*, which is at leaſt 14 Times farther than the Orbit of *Saturn*, the Boundary of the Planetary Syſtem. ——The *Light and Heat* therefore of that Comet is then near *two Hundred Times* leſs than at *Saturn*, and above 17 *Thouſand Times leſs* than with us; thus the Light and Heat of *Saturn* is much more intenſe, compared with the Comets, than ours in Compariſon of *Saturn*'s.

Euphroſ. Oh! *Cleonicus*, were it not for the Power of Numbers, we could never be able to form Ideas of ſuch extreme Degrees of Cold and Heat! for its Heat, I ſuppoſe, if compared with ours, is as ſurpriſing.——

Cleon. And much more ſo: For being, when neareſt the Sun, about *one Hundred ſixty ſeven Times* nearer the Sun than the Earth, and *ſixty five Times* nearer than *Mercury* itſelf: the Light and Heat therefore, at that Time at the Comet muſt be at leaſt *four Thouſand Times* greater than in *Mercury*; and no leſs than *twenty eight Thouſand Times* greater than in our *torrid* Zone. What think you of that?

Euphroſ. Think! what ſhould a Woman pretend to think of ſuch Matters, as I believe I may venture to ſay, ſurpaſſes the moſt philoſophical Heads; and which they can give no juſt Account of? Or, am I miſtaken, *Cleonicus*?

Cleon. Very little; for though it be poſſible to produce a ſmall circular Spot of Heat by Means of a burning Glaſs, that ſhall have a Degree of *Ardour* equal to that at the Comet; that this Spot can bear no Proportion to the glowing Globe of the Comet in Point of *Heat*, than it does, perhaps, in Magnitude, which is infinitely ſmall.

Euphroſ. Can you tell any Thing of the Magnitude of a Comet, *Cleonicus?*

Cleon. I do not remember that there is any certain Menſuration of the Comet; tho' there is ſufficient Reaſon to believe that they are ſome leſs, ſome equal to, and ſome bigger than the Moon; for they are but ſmall, and it is their Tail that makes them ſo conſpicuous.

Euphroſ. But, pray, what is that you call the Tail *of the Comet?*

Cleon. It is a prodigious Quantity of Fume and Vapours flying off from the Body of the Comet, as it becomes more and more heated in its Approach to the Sun.

Euphroſ. No Wonder there ſhould be ſuch an Evaporation, conſidering how ſo cold a Body is gradually ſo intenſely heated; What Particulars do you obſerve of a Comet's Tail?

Cleon. The following. (1.) They ſeem largeſt and moſt ſplendid immediately after they return from the Sun; becauſe being then hotteſt they emit the greateſt Quantity of Vapours. (2) The Tail lies always towards thoſe Parts, which the Body of the Comet leaves in its Deſcent; which is agreeable to the Nature of Smoke and Vapour. (3) They appear broader on their upper Part than near the Head of the Comet; as all Vapours, the higher they riſe the more they dilate themſelves. (4) The fixed Stars are often ſeen through the Tails of Comets; which prove they conſiſt of a very fine and pellucid Vapour. (5.) The Tails of Comets are extremely long; ſome having been computed to be not leſs than *eighty Millions of Miles* in Length.

Euphroſ. Well, Nothing would more delight me, than to have but a probable Uſe of thoſe Prodigies of Nature aſſigned! Can you ſay, *Cleonicus*, to what End the Almighty has appointed thoſe wondrous Bodies.

Cleon No, I can ſcarce conjecture at it; the Ancients (who were entirely ignorant of their Nature) eſteemed them a Sort of Meteors kindled in the Air, and portending ſome extraordinary Event. As *Hudibraſs* merrily expreſſes it.——

Portending Blood like blazing Star,
The Becon of approaching War.

Or, thus more ſeriouſly, *Homer.*———

As the red Comet from Saturnius *ſent*
To fright the Nations with a dire Portent,
(A fatal Sign to Armies on the Plain,
Or trembling Sailors on the wat'ry Main)
With ſweeping Glories glides along in Air,
And ſhakes the Sparkles from his blazing Hair.

Euphroſ. I do not much regard the Opinion of the Ancients; Pray, what do the Moderns, and the moſt judicious among them, take the Comets to be?

Cleon. Some, (and not a few) think they are appointed as the Places of Torment for the damned; that is, that each Comet is, properly and literally ſpeaking, *a Hell*; from the intolerable and inconceiveable Heat and Cold which is found alternately in thoſe Bodies. To this agrees the Poet.

Who can the Comet's wond'rous Journey tell;
Seats not unaptly deem'd the Place of Hell.
Now burning in the Sun's immediate Beams;
More frigid now than Greenland's *frozen Streams.*
Of all God's Works, our Reaſon Nothing ſhows,
So fitly form'd for Torments and for Woes.

Euprhoſ. O dreadful, *Cleonicus*! What, every Comet a Hell! Surely the Philoſophers begin to preach very terrible Doctrine indeed; how will ſuch receive a *Plurality of Hells*, who can ſcarce think it conſiſtent with the Goodneſs and Mercy of God to appoint any Hell at all!

Cleon. You muſt conſider, Siſter, that what is ſaid on this Head, is Nothing but Conjecture; there are ſome other Uſes aſſigned to Comets, which to ſome Philoſophers appear very probable.

Euphroſ. What are they?

Cleon. Some ſuppoſe, that they are the Means appointed by the Almighty for putting a Period to the Planetary World; either by involving the Globe of the Planets in their Atmoſphere of Water, in their Return from the cold Regions, and ſo drown them by a general Deluge or Flood, as was the Caſe, according to ſome, of our Earth in the Time of *Noah.*

Euphroſ. Hold: Pray anſwer me a Queſtion, which I can ſcarce aſk without trembling; Do the Comets indeed paſs and repaſs in their Orbits ſo near the Orbit of the Earth, as to endanger it in the Manner you repreſent by their near Approach? If ſo, then we are not only liable to be drowned on one Hand, but burnt to Death on the other; if the Comet ſhould take us in his Return from the Sun.

Cleon. Indeed, my *Euphroſyne*, the Caſe ſeems to be very much ſo; it has been ſhewn that the Comets of the Year 1618, and 1684, came very near the Earth's Orbit; and particularly that of 1680, *Nov.* 11. at one o'Clock in the Afternoon was at ſo ſmall a Diſtance, that had the Earth been about that Part of its Orbit, God only knows what the Conſequences might have been of ſo near an Appulſe of ſo terrible a Body! If a Comet ſhould thus encounter the Earth at its Return from the Sun a little too nearly, it would undoubtedly conſume the Earth, and all its Inhabitants, as ſo many Moths; it might convert the Matter of the preſent Earth into a different Kind of Subſtance, and render it an Habitation fit for Beings of a quite different Nature from ours.

Euphroſ. Upon my Word, *Cleonicus*, you have made me almoſt afraid to live upon the Earth. As the beſieged in a Town expect and fear the dire Approach, and Fall of Bombs, ſo the Inhabitants of the Earth may fear the ſudden, dreadful Shock of Comets, and expect one Day or other to have the Globe daſhed to Pieces about their Ears, and themſelves abſorbed in an Abyſs of Water or Fire!

Cleon. Be not diſmayed, *Euphroſyne*; theſe are great, but rare Events; for, though they are poſſible in Nature, yet ſome Things make it a very great Chance if they happen at all with regard to any definite Time. For the Plains of all the Comets Orbits are raiſed above thoſe of the Planets; ſo that there is but one particular Place in the Orbit of a Comet where its Tail can paſs over the Orbits of the Planets; and it is ſo many Chances to one, that a Planet happens to be in that Part of its Orbit at that particular Time, that we have no Reaſon to fear any ſuch Cataſtrophe: And they, who have talked about ſuch terrible Things, may be rather ſaid to have *dreamed*, than demonſtrated any ſuch future Events.

Euphroſ. But pray, *Cleonicus*, can you aſſign any more innocent and leſs terrifying Uſes of Comets, than thoſe you have mentioned?

Cleon. Yes; ſome Philoſophers, and thoſe of the firſt Rank, imagine, that, by the Rarefaction and ſpreading of the Vapours of the Tails of Comets, they ſupply the Planets with Moiſture, which they ſuppoſe continually decreaſes by Vegetation, Putrefaction, *&c.* They alſo farther ſuppoſe, that Comets, in their ſeveral Revolutions, approach nearer and nearer to the Sun, till at laſt they fall into, and ſupply the Sun with freſh Fuel, Fire, and Heat. But how Comets ſhould do this, without they conſiſt of a very combuſtible Matter, of a much larger Bulk, and made much quicker Returns, is not very eaſy to conceive. And thus I have told you, as much as is generally known of the Comets; and ſhall at preſent conclude with Mr. *Baker*'s Deſcription of a Comet in the following Lines.

At his Command, affrighting human Kind,
COMETS *drag on their blazing Lengths behind:*
Nor, as we think, do they at Random rove,
But, in determin'd Times through long Ellipſes move.
And though ſometimes they near approach the Sun,
Sometimes beyond our Syſtem's Orbit run;
Throughout their Race they act their Maker's Will,
His Power declare, his Purpoſes fullfil.

Univerſe, Page 19.

Plate X.

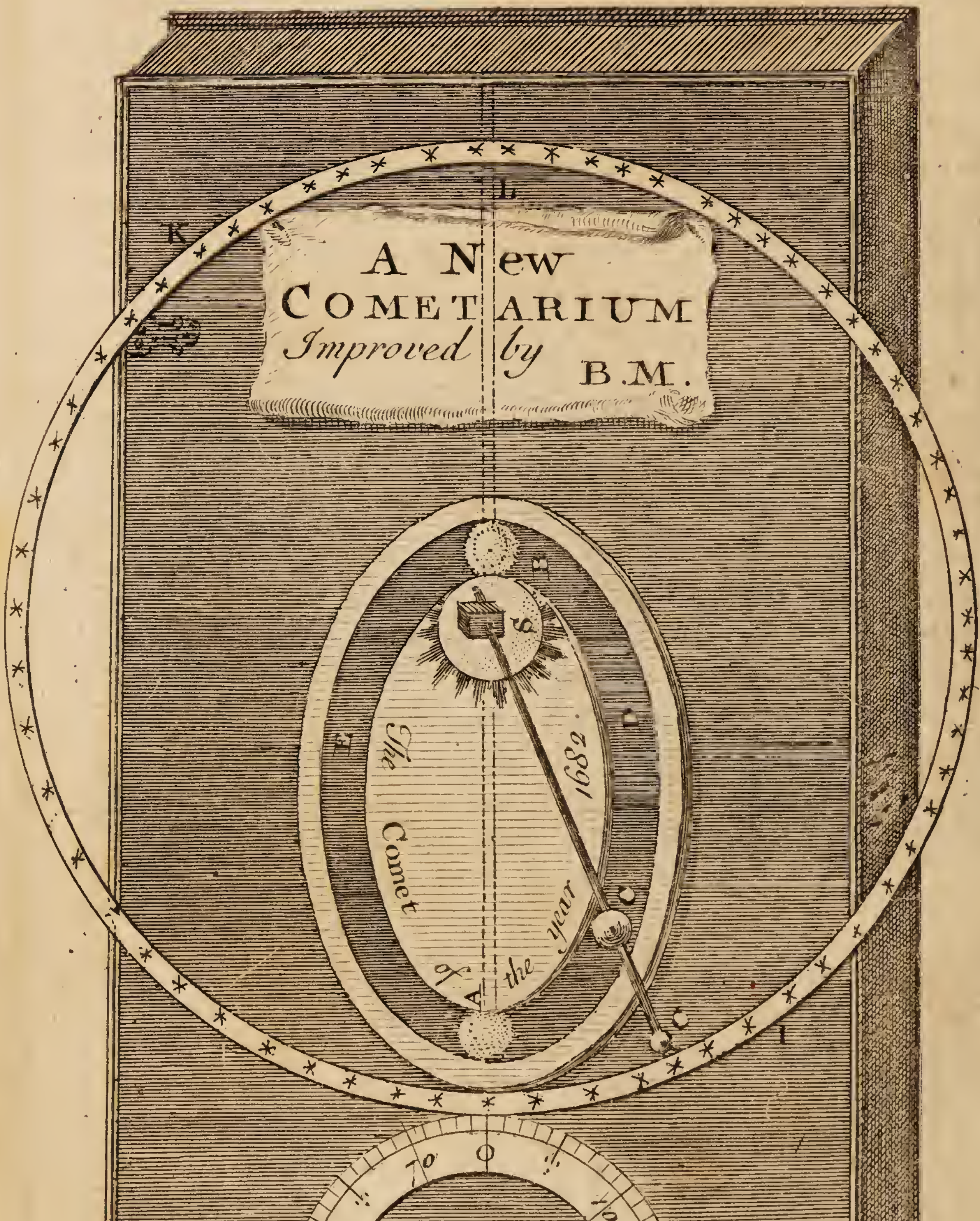
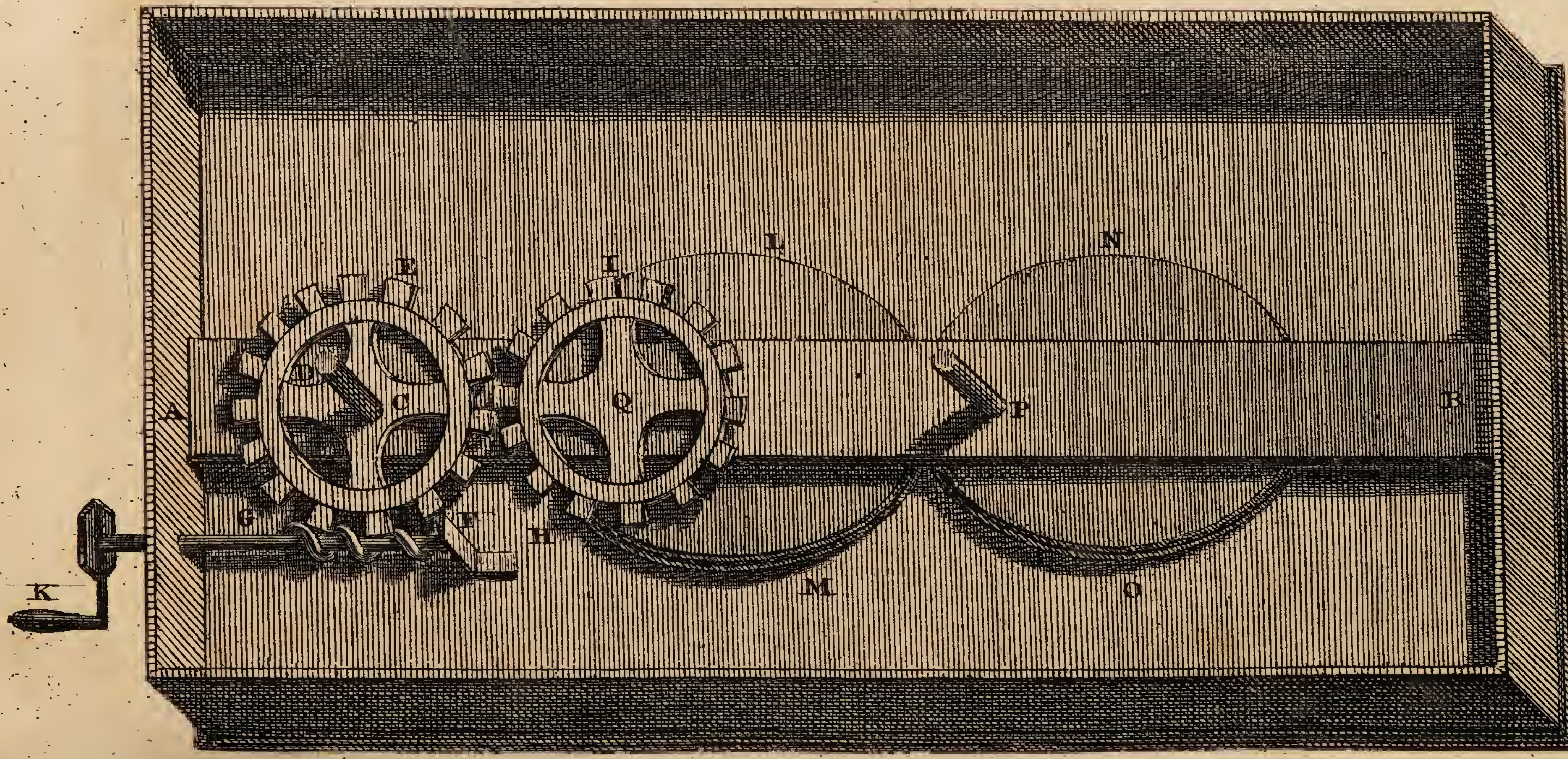

A New
COMETARIUM
Improved by
B.M.
K
L
B
S
E
D
The Comet of the year 1682
A
C
I
F
G
H
0
70
10
60
20
50
30
40

Plate XI.

A View *of the* Wheel-work *of the* COMETARIUM.



DIALOGUE XVI.

On the Uſe of the COMETARIUM.

Euphroſyne.

SINCE you gave me the Lecture on Comets, you have filled my Head with ſuch odd kind of Ideas, that I ſcarcely know whether I hope or fear moſt to ſee a Comet; but dear *Cleonicus*, ſince that is ſhortly to be the Caſe, and a Comet we muſt behold, if your *Aſtronomical Prediction* is to be regarded, I think I may as well take Courage, and reſolve to attend the important Event undauntedly.

Cleon. Fortitude, my *Euphroſyne*, is an excellent Virtue; and here I muſt admoniſh you to ſpeak with more Reverence of aſtronomical Predictions, or elſe you may chance, one Day or other, to be accoſted in the *Pontifical Style*, and be told, *That Aſtronomers only have Infallability on their Side*; *that their Prophefies are ſacred and certain Truths*; *that they muſt be believed, or that an implicit Faith in all they ſay is your higheſt Duty, and abſolutely neceſſary to your future Reputation*; *that*———

Euphroſ. Hold, *Cleonicus*, too much of this kind of Denunciation does not ſound well after a *liberal Education*; you are now talking to a Woman, and they are frail Creatures, God knows; if we ſhould be guilty now and then of a little *aſtronomical Infidelity*, we hope it may be looked upon as a *venal* Crime, and for which we may be entituled to an *Indulgence*.

Cleon. You are quite on the right Side of the Queſtion, Siſter; the Ladies are ſure to be forgiven, with or without *Confeſſion.*———Now we are on this Subject, what will you think of a Propheſy or Prediction of a Heathen, the celebrated *Seneca*, in the following Words?

" I cannot aſſent to our Philoſophers, nor think the Comets
" are Fires ſuddenly kindled, which appear a-while, and are
" then extinguiſhed; but I reckon them among the eternal
" Works of Nature———And why ſhould we wonder that
" Comets (ſuch a rare Spectacle in the World) ſhould not yet
" be reſtricted by certain Laws; nor have the Times of their
" appear-

"appearing or diſappearing known, as they take their Courſes
"through ſuch prodigious Intervals of Space.——The Time
"will come when a Day ſhall bring to light, and the Diligence
"of a future Age diſcover, thoſe Things which now lie hid.

"The Time will come in which Poſterity will wonder that
"we were ignorant of Things ſo very plain.———A Perſon
"ſhall one Day ariſe, who ſhall demonſtrate into what
"Regions the Comets wander, why they move ſo ſeperately
"from the reſt of the Planets, and how large, and what kind
"of Bodies they are."———

I ſay, dear Siſter, what can you think of all this, when if you could read Sir *Iſaac*'s *Principia*, and there ſee every Particular of this whole Prediction fulfilled to a Tittle, and no other Man beſides Sir *Iſaac* did ſo much as even to attempt the arduous Taſk.

Euphroſ. Think, why what could one think leſs than that he propheſied of that very great Man.——But though I am not able to underſtand the Writings of that Philoſopher, yet, if I remember right, you once told me, that you could make the Manner of the Comet's Motion intelligible by a proper Inſtrument, as well as thoſe of the Planets.

Cleon. I did ſo; the Inſtrument I mean is called the COMETARIUM, and which I ſhall now ſpend one Quarter of an Hour in explaining it to you.——Here is the Machine.——

Euphroſ. And a beautiful one it is; I can almoſt tell the Uſe of it by its very Appearance; the Braſs-ball C, is the Comet, I dare ſay; and the long oval Groove, the Orbit in which it is to move about the Sun, which I obſerve is engraved at one End of it.

Cleon. Very right, my *Euphroſyne*, this Inſtrument ſhews the Motion of the Comet of the Year 1682, whoſe Period is 75½ Years.

Euphroſ. Then that Period, or thoſe Years, I ſuppoſe, are repreſented by the Circle FG, and the Hand H, pointing out the particular Year of the Period, for any Poſition of the Comet in its Orbit: am I right *Cleonicus?*

Cleon. So very good is your Apprehenſion, that it almoſt makes a Deſcription of the Inſtrument unneceſſary.

Euphroſ. Not ſo, indeed; for I can ſcarce tell what Uſe that long Wire is of that goes through the Body of the Comet, or of the little Ball E at the End of it; or the Meaning of the large Circle of Stars, though I partly gueſs at them too.——

Cleon. Theſe Things will all be eaſy to *Euphroſyne* when the Machine is in Motion.——Obſerve, when I turn the Winch, the brazen Comet moves, and with a very uneaqual Pace in its elliptic Orbit, about the *focal Sun* at S.———That when it is neareſt the Sun (in what is called the *Perihelion* at B) it moves very quick,——and, on the contrary, at its greateſt Diſtance (or Aphelion at A) it moves extremely ſlow;—and conſequently, that in its Return to the Sun, its Motion is always *accelerated*, and conſtantly *retarded*, as it recedes from the ſolar Focus.

Euphroſ. All this I obſerve and underſtand with Pleaſure.—But now for the Reaſon of it, *Cleonicus*, if I muſt be a Philoſopher, let me be a rational one or none at all.——Why moves the Comet with ſuch an unequal and variable Motion?———When it is got ſo far off, what brings it round again, or why does it not keep on increaſing its Diſtance from the Sun, and with a decreaſing Motion arrive at laſt ſomewhere at a State of Reſt?

Cleon. Why, truly, my *Euphroſyne*, theſe are very reaſonable Queries, but they are more eaſily aſked, than their Solutions are to be underſtood, till you have made a little further Progreſs in the Elements of Aſtronomy. I can only ſay at preſent, that one Reaſon of the Comet's Motion, is the *Power of Gravity*, by which it tends towards the Sun in every Place; and becauſe this Power is greateſt when the Diſtance is leaſt, the Comet will there of Courſe move quickeſt; and at greater Diſtances, where the Force of Gravity is leſs, the Motion will be retarded and become ſlower in Proportion. But there are other Cauſes co-operating to produce this ſort of Motion, and when they are explained by Experiments hereafter to be made, you will ſee the Reaſon why the Comets muſt neceſſarily return, and move in elliptic Orbits.

Euphroſ. I am content to ſtay till then, though I fear it will be a pretty while firſt.———But, *Cleonicus*, is not the Uſe of that Wire to keep the Comet in the Groove, and to oblige it, at the ſame Time, to move about the Sun?

Cleon. It is juſt the Thing you mention;——and farther, you obſerve the Part of the Wire beyond the Comet, grows gradually longer as the Comet approaches the Sun, and ſhorter as it returns from the Sun; and that therefore, it does, in ſome Meaſure, not unaptly reſemble the *Comet's Tail?*

Euphroſ. Indeed it will ſerve for that Purpoſe very well, and naturally enough repreſents the Riſing and Encreaſe of that wonderous Exhalation, as the Comet approaches to the Sun, and its gradual Diminution as it retreats from the ſame.——But does not that little Ball at the End of the Wire, anſwer ſomewhat like the ſame Purpoſe as the Bead in the ſtellated Planetarium for the apparent Motion of *Venus?*

Cleon. In part it does, but not altogether.——Here you are to ſuppoſe an Eye placed in the Sun and viewing the revolving Comet in its Orbit; the apparent Motion of the Comet in this Caſe, would be ſhewn by the ſmall Ball among the Stars in the Sky, as that Ball appears, to ſuch an Eye, to move by the Stars on the Circle IK. And the Inequality of the apparent Motion of the Comet among the Stars, is much greater than that of its true or real Motion in its Orbit.

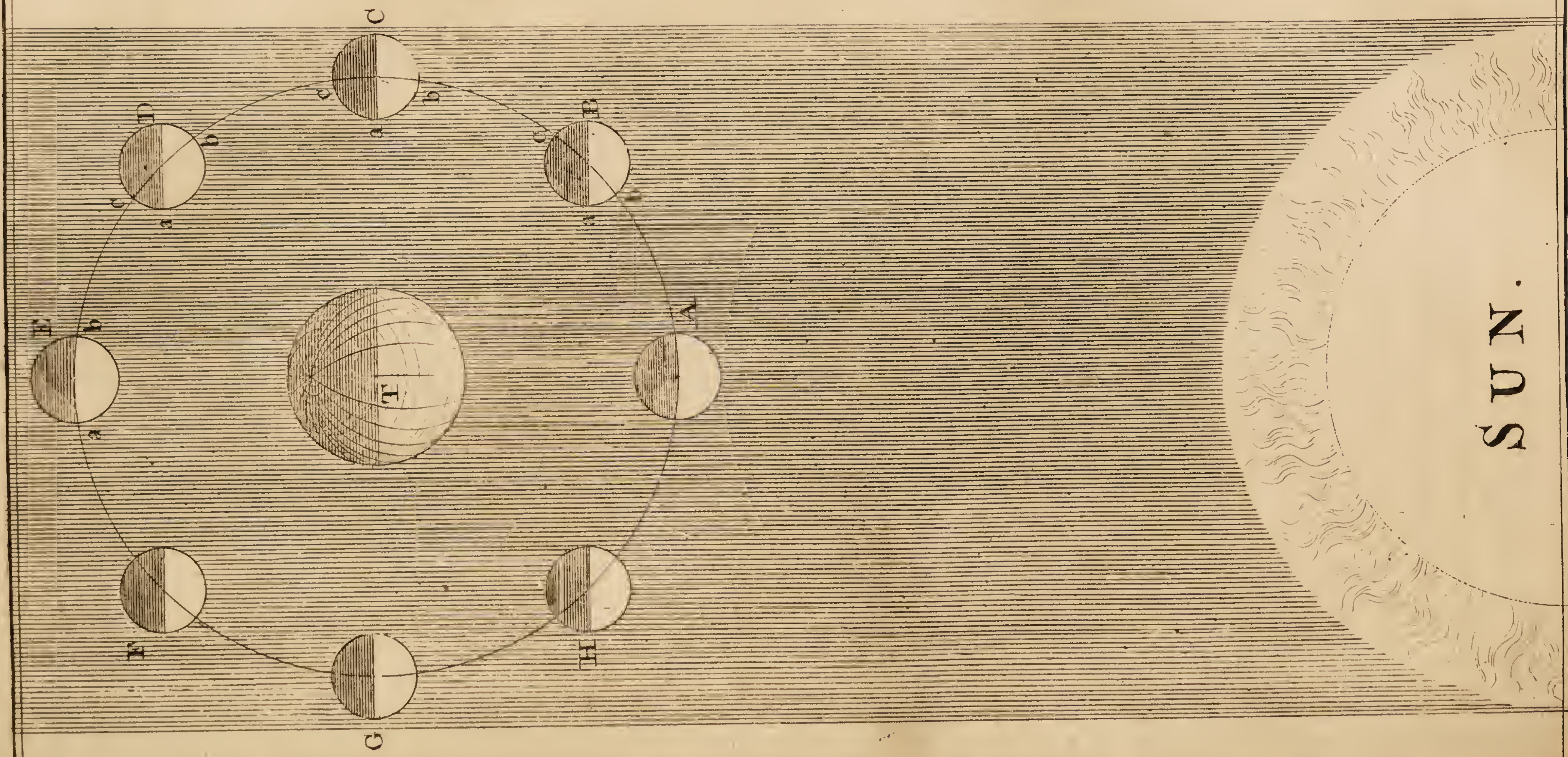
Euphroſ. Can you make this Matter intelligible to ſuch a Novice as I am, think you, *Cleonicus?*

Cleon. I make no Doubt of it; for firſt, you obſerve that the true Velocity of the Comet is ſlower in its Aphelion at A, than in the Perihelion at B, and it is juſt ſo much ſlower as the Diſtance is greater, *viz.* As SA is greater than SB. But, ſecondly, when the Comet is at B, in its neareſt Diſtance, it is ſlower than the ſmall Ball upon the ſtarry Circle at L, in Proportion as the Diſtance of the Comet SB, is leſs than the Diſtance of the Ball SL. Therefore, upon the Whole, by the Velocity of the Comet at its greateſt Diſtance at A ſeen from the Sun, or upon this Inſtrument, is as much leſs than the apparent Velocity of the ſame Comet among the Stars at L, when the Comet is neareſt of all to the Sun at B, in Proportion as *the Square of the greateſt Diſtance* SA, *is to the Square of the leaſt* SB.

Euphroſ. If I do not nicely underſtand your Proportion of Squares, and ſuch Things, you muſt excuſe me, at preſent. ——I can plainly enough ſee the Difference of the Motion in thoſe two Places is prodigiouſly great, and an extremely pleaſing

The SUN Enlightening the EARTH and MOON.

Plate XII.



pleaſing Phænomenon it is——But ſay, *Cleonicus*, how will the Comet appear to move to an Eye on the Earth, to us for Inſtance, when the next comes round?

Cleon. The Comet always appears to us to move in a great Circle through the Heavens; to go forwards, and backwards at Times; to riſe before, and ſet after the Sun; and ſuch other Phænomena as we obſerved of the Planets, which, were it neceſſary, we might explain in the ſame Manner as was then done; but of theſe Things I ſhall give you a more particular Account when the next Comet appears, and illuſtrate each Phænomenon by Experiments on the Comet itſelf.

Euphroſ. Truly, you almoſt make me wiſh for the Comet's Return; the Thing which before filled me with Apprehenſion and Horror, you have now rendered not only not dreadful, but even deſirable.

Cleon. It is always one good Effect that Philoſophy has, to deliver the Mind from the Infamy of Ignorance, and thoſe baſe Sentiments and ſlaviſh Fears that continually ſubject it to unneceſſary Pain and Anxiety. In ſhort, it gives the ingenious and liberal Mind a Pleaſure in viewing thoſe Phænomena of Wonder-working Nature, which vulgar and ſuperſtitious Souls conſtrue into direful Omens and Prodigies of Fate; and ſcare themſelves, and their unthinking Neighbours, with Notions of divine Wrath and Judgment much oftner than there is Occaſion for.

Euphroſ. You ſpeak Truth undoubtedly; yet our Frame will be ſomewhat ſhaken at ſuch amazing and unuſual Appearances. ——I think you ſaid the next Comet will appear in the Winter of the Year 1757; I ſuppoſe that is ſhewn by the Motion of the Hand H, of the Circle GH, divided into 75 ½ equal Parts, over which it moves, I ſee, in one Revolution of the Comet.

Cleon. That is the very Caſe; for you obſerve when the Comet is neareſt the Sun at B, the Index H of the Circle of Years, points to the Beginning of that Circle, or O; after which, as the Comet revolves, the Index points to 10, 20, 30, *&c.* ſhewing the reſpective Places of the Comet for every ten Years of the Period. And ſince in 1682, this Comet was in its Perihelion at B, it will be at its Aphelion at A, in half the Time of the Period, *viz.* 37 ¾ Years, which was in the Year

1720; therefore if to this we add the other Half, it will bring it again to its Perihelion B, which will be 1757 $\frac{3}{4}$, or rather in the Spring of the Year 1758; but for the particular Time to a Week or a Month, we cannot anſwer; it is ſufficient that at preſent we can predict a Comet will nearly about that Time return.

Euphroſ. Well, *Cleonicus*, I cannot ſay but your *Cometarium* gives me an agreeable Foretaſte of the exquiſite Pleaſure that ſuch a Phænomenon will afford me when it happens in Reality. — But my Curioſity is not yet quite ſatisfied; methinks I ſhould be glad to ſee the Inſide of this Inſtrument,——could you oblige me in this Reſpect without too much Trouble?

Cleon. Nothing is more eaſy— I only take off the Wire and Index; it is then but a common Box— I unlock and lift up the Lid, and you ſee the Simplicity of the Mechaniſm at once.

Euphroſ. There is but a ſmall Matter of it, indeed,— only two *circular* and two *oval Wheels*, as I may call them; I ſhould have thought there muſt have been more Work neceſſary to have produced ſuch an inequable, yet regular and extraordinary Motion, as that of a Comet.

Cleon. * On the long Piece of Wood AB, are placed two circular Wheels, EF and IH, the firſt of theſe is turned by the Worm or endleſs Screw G, by the Handle K: The Axle CD of this Wheel goes through the Lid, and carries the Hand H over the Circle of the Comet's Period. (*See Plate* X.) The ſecond Wheel IH above, and the elliptic Wheel LM, below the Bar AB, are both fixed on the ſame Axle, and therefore muſt both move together. The other elliptic Wheel NO, is conected with the former by a Cat-gut Line in a Groove made in the Perimeter of each oval Wheel. And the Axle P, fixed in the Focus of this Wheel, does alſo go up through the Lid or Cover, and carries the Wire and Comet upon it, as you ſaw on the Top of the Inſtrument. Now it is to be obſerved, that the Edge of the ſecond Wheel NO, is conſtantly applied to that of the firſt Oval LM, and is moved by it always at unequal Diſtances from the Center, or rather Focus Q, and therefore the Motion muſt needs be very unequable, while that of the circular

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* See Plate XI.

Wheels is conſtantly the ſame. Whence by this Contrivance, an *equal Motion*, you ſee, *produces a very unequal one*; which is a Sort of mechanic Paradox.

Euphroſ. Truly it is, *Cleonicus*, and I could never have thought which Way it was to be done; and I cannot but admire the ſingular Structure, and curious Mechaniſm of the Parts —— To ſee an uniform Motion in the circular Wheels;— A different Motion in every different Part of the firſt oval Wheel, and yet in the ſame Part the Motion is uniformly and always the ſame — And laſtly, to ſee ſo very unequal a Motion in every Part of the ſecond Oval; I ſay, to obſerve ſo many variable and diſſimilar Effects in ſo ſmall and ſimple an Inſtrument; and at the ſame Time explanatory of the moſt unuſual and extraordinary Phænomena of the Syſtem, is what inſtructs and entertains me beyond any Thing I could have imagined.— But I fear I have kept you too long upon a Subject, which, however new and engaging to me, may in ſome Degree prove tedious to you, who underſtand it ſo well.

The Young GENTLEMAN and LADY's PHILOSOPHY.

PART II.

DIALOGUE I.

Of the MOON.

Euphroſyne.

OUR laſt Converſation, *Cleonicus*, concluded our Speculations of the larger Cœleſtial Bodies of the Syſtem, *viz.* the *Primary Planets* and *Comets*; the Order of our Method, I preſume, brings us now to thoſe of the *Secondary Claſs*.

Cleonicus. Yes, as we have conſidered the Sun the Center of the Great Syſtem, about which the *Chorus* of the largeſt Planets move; ſo now we ſhall proceed to conſider the Bodies of ſome of thoſe Planets as the Center of a leſſer Syſtem of *Secondaries:* And of theſe we have but three, *viz.* the *Earth*, *Jupiter*, and *Saturn*.

Euphroſ. To the Earth you aſſign one Moon; to *Jupiter*, four; and to *Saturn*, five, if I remember right.

Cleon. 'Tis very right: Of theſe we will diſcourſe in Order, beginning with the *Moon* pertaining to the Earth; which as it is the neareſt of all the heavenly Bodies to us, ſo it appears the moſt perfect, either by the Eye or Glaſs; and exceeds even the Sun itſelf in its apparent Magnitude. No Wonder, therefore, *Moſes* ſhould call it a *great Light*.

Euphroſ. I remember *Milton*'s Deſcription of the Creation of the Moon, which is very beautiful. Having deſcribed that of the Sun, he ſays,

——————— *Leſs bright the* Moon,
But oppoſite in levell'd Weſt was ſet,
His Mirror with full borrowing her Light
From him, for other Light ſhe needed none
In that Aſpect, and ſtill that Diſtance keeps
Till Night: Then in the Eaſt her Turn ſhe ſhines
Revolv'd on Heav'n's great Axle; and her Reign
With thouſand leſſer Lights dividual holds.
With thouſand thouſand Stars that then appear'd
Spangling the Hemiſphere.———

Cleon. To your Deſcription from *Milton,* I ſhall add that of Mr. *Cowley,* which has a peculiar Beauty and Sweetneſs.

He ſmooth'd the rough-caſt Moon's imperfect Mold,
And comb'd her beamy Locks with ſacred Gold;
Be thou, ſaid he, Queen of the mournful Night,
And as he ſpoke, ſhe roſe o'er-clad with Light;
With thouſand Stars attending on her Train,
With her they riſe, with her they ſet again.

Euphroſ. This is a ſweet Deſcription indeed; but let us have a little Philoſophy with the Poetry. I have a great many Queſtions to aſk about the Moon; and pray, in the firſt Place, what Diſtance may ſhe be from the Earth?

Cleon. The true *Diſtance* of the Moon from the Earth is always variable; being ſometimes greater, ſometimes leſs; but when neareſt, ſhe is diſtant from us about *two hundred and twenty thouſand Miles.*

Euphroſ. Well, the next Queſtion of Courſe is of her *Magnitude.*

Cleon. The Moon is in Diameter *two thouſand one hundred and ſeventy-five Miles.* Wherefore the Moon is about 50 Times leſs than the Earth.

Euphroſ. But as I remember, ſhe is near as big as the Planet *Mercury.*

Cleon. Yes, ſhe is ſo; but *Mercury* being above *one hundred and forty Times* farther from us, is the Reaſon why he appears ſo ſmall, and ſhe ſo large, in Compariſon of each other.

Euphroſ. What is the preciſe Time of her Revolution about the Earth?

Cleon. She moves from *Weſt* to *Eaſt*, in about 27 Days, ſeven Hours, and 43 Minutes.

Euphroſ. I think there is no other apparent Motion of the Moon but that each Day from Eaſt to Weſt, which, I preſume, you impute to the daily Motion of the Earth about its Axis.

Cleon. You are right in what you ſay laſt; but even the Moon's periodical Motion about the Earth, is apparent enough, if well obſerved: For, ſuppoſe the Moon were this Night juſt by any fixed Star, if you obſerve her To-morrow Night at the ſame Time, you will ſee her at a conſiderable Diſtance from that Star towards the Eaſt; and the ſecond Night twice as far Eaſtward; and ſo on, till ſhe has performed a Revolution, and comes in Conjunction with the Star again; advancing each Day a very ſenſible Diſtance Eaſtward.

Euphroſ. This is an Obſervation I ſhall be very well pleaſed with, and will prove it the firſt Opportunity. But, pray, *Cleonicus*, has the Moon any other Motion but that about the Earth now mentioned?

Cleon. Yes, ſhe moves about her own Axis too.

Euphroſ. In what Time?

Cleon. Juſt in the ſame Time as ſhe moves round the Earth.

Euphroſ. Indeed! Why the Moon has ſomething very ſurprizing and peculiar in her Motion.

Cleon. She has ſo; *her Days and Months are of an equal Length*; which can be ſaid of no other Body in the Heavens that we know of.

Euphroſ. But how do you prove this, by any Method that I can underſtand?

Cleon, Yes, very eaſily; for conſidering the Moon as a Globe revolving round the Earth as a Center, having its Superficies all over variegated with light and dark Parts, it will from thence be eaſy to conceive, that if different Parts of the Superficies be at any Time turned towards the Earth, it will by that Means be very diſcernable to a Spectator at the Earth.

Euphroſ. Undoubted it would, from the different Appearance of thoſe Parts or Spot.

Cleon. But you know this would neceſſarily be the Caſe, were the Moon to be view'd in different Parts of her Orb, ſuppoſing ſhe had no other Motion.

Euphroſ. I conceive it would, for all the Part, or Hemiſphere, turned towards us in one Part would be quite hid from us in the oppoſite Part; and all the Parts viſible in the firſt Caſe muſt be now inviſible.

Cleon. Very good, my *Euphroſyne:* But ſince you obſerve that in what ſoever Part of the Orbit the Moon is in, the ſame Face, or the ſame Appearance of Spots is always obſerved, without any ſenſible Variation, ſhe muſt of Neceſſity have ſuch a Motion about her own Axis as turns every Moment ſo much of her Superficies from our View, as is turned to us by her periodical Motion; that is, ſhe muſt move in the ſame Time about her Axis as ſhe does about the Earth.

Euphroſ. Your Reaſoning is certainly very juſt, and amounts to a Demonſtration. But why muſt it be ſo? Why, *Cleonicus*, was it not permitted us to ſee the other Half of the Moon's Surface?

Cleon. The Almighty only knows! Any other diurnal Motion but what it has would have gratified our Curioſity with that pleaſing Proſpect, from which we are now eternally excluded. But as it may not only be ſatisfactory, but alſo inſtructive to ſee this Matter repreſented in the *Planetarium*, from the ſame Cauſe as produced in the Heavens, *viz.* the Power of Attraction — Therefore, you obſerve, on the central Part I place the Earth, and at a Diſtance, on a proper Stem I ſuſpend an Ivory Ball by a String, ſo that it is free to move any Way.—But now the Machine is in Motion. You obſerve the Ball which repreſents the Moon keep moving about the central Earth, but ever with the ſame Part towards it, while the Earth itſelf is conſtantly turning all Parts of its Surface towards the Moon.

Euphroſ. I can't but obſerve it with equal Curioſity and Wonder. But you know my inquiſitive Temper, and you muſt ſhew me the Reaſon of the Thing before I ſhall be ſatisfied.

Cleon. I am never better pleaſed than to find ſuch a Diſpoſition in Pupils.——You are ſoon convinced of the Reaſon of this Phænomenon—I take the Earth off from a ſmall Stem of Steel, which is an *artificial Magnet*, and there is a Piece of a natural Magnet within the Ball or Moon, and the Power of Magnetiſm here cauſes the Moon always to ſhew or turn the ſame Part towards the central magnetic Earth juſt as it is effected by the *Power of Gravity* in the Heavens.—Hence not only one Half of the Moon is conſtantly hid from us, but our Earth is alſo at the ſame Time unſeen by thoſe who inhabit that inviſible *Lunar Hemiſphere*, for you will eaſily underſtand *that thoſe we cannot ſee can never ſee us.*

Euphroſ. That is a very plain Caſe—and one Thing more I obſerve, *Cleonicus*, and that is, the Side of the Moon next to the Earth is never dark; for it is always illumined by the Sun's direct Beams on one Part, or by thoſe Rays reflected from the Earth on the other.

Cleon. What you ſay is very true; the Earth is (as I may truly ſay) a noble Moon to thoſe Lunarians who are bleſſed with a Sight of it.—Our full orbed Earth is a Moon more than ſixteen Times as large to them as their puny Moon is to us.—They alſo ſee the pleaſing Appearance of Land and Water, fiery Meteors, Clouds, nay our Towns and Cities are ſeen by them, (if they did but know it) in each Revolution on the Earth.

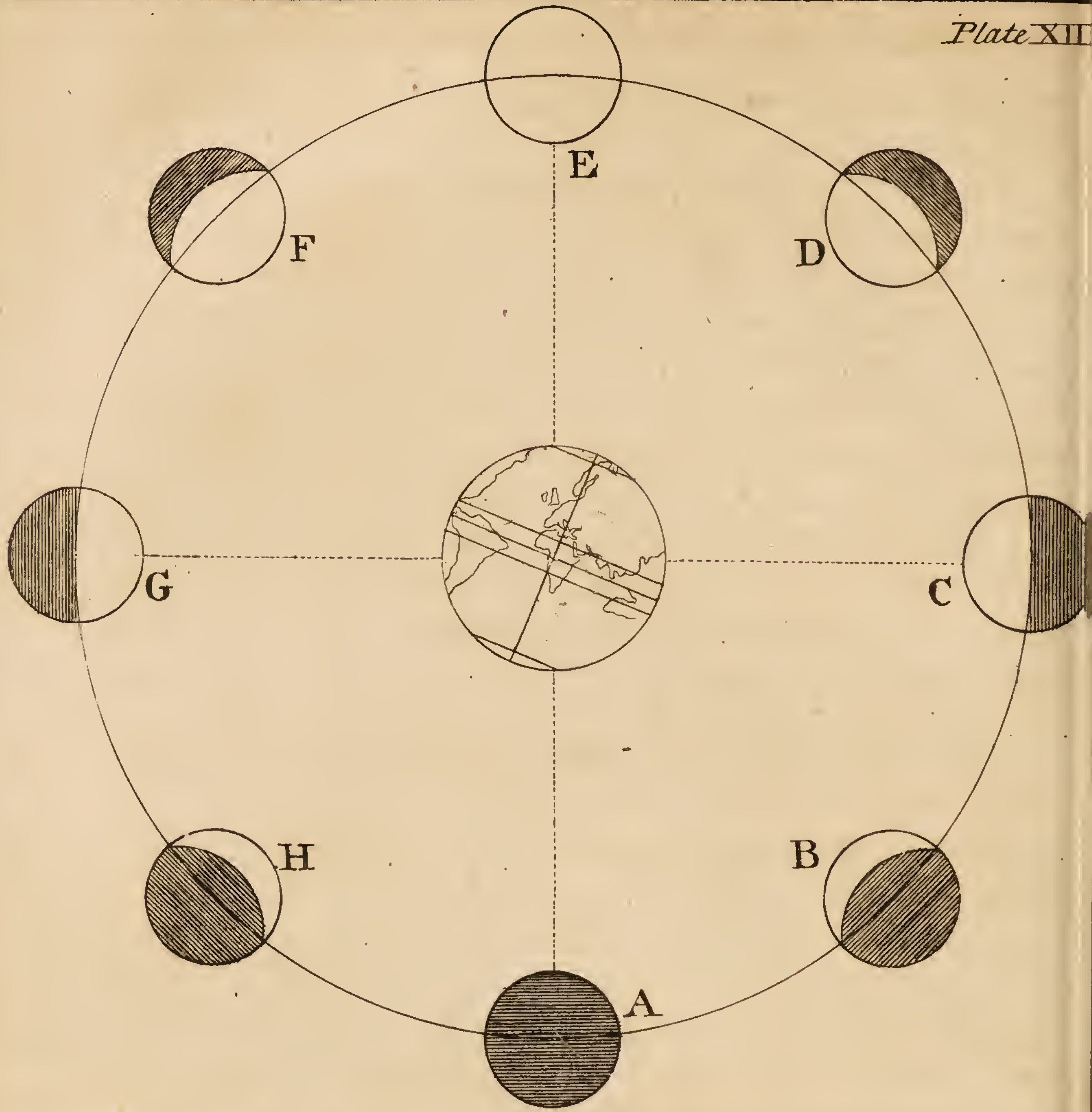
Euphroſ. Well, I almoſt envy them the Pleaſure.—But let us make the moſt of that Part of the Moon we are permitted to ſee, which if you pleaſe to ſhew me thro' a Teleſcope as you promiſed, I am perſwaded it will afford me an agreeable and delightful Spectacle.

Cleon. That, my *Euphroſyne*, I'll readily do; and through ſuch a Teleſcope as will juſt take in at one View her full enlightened Orb, which now you ſee riſing with ſuch Majeſty, and advancing up her arched Path with ſolemn Pace in yonder eaſtern Sky.

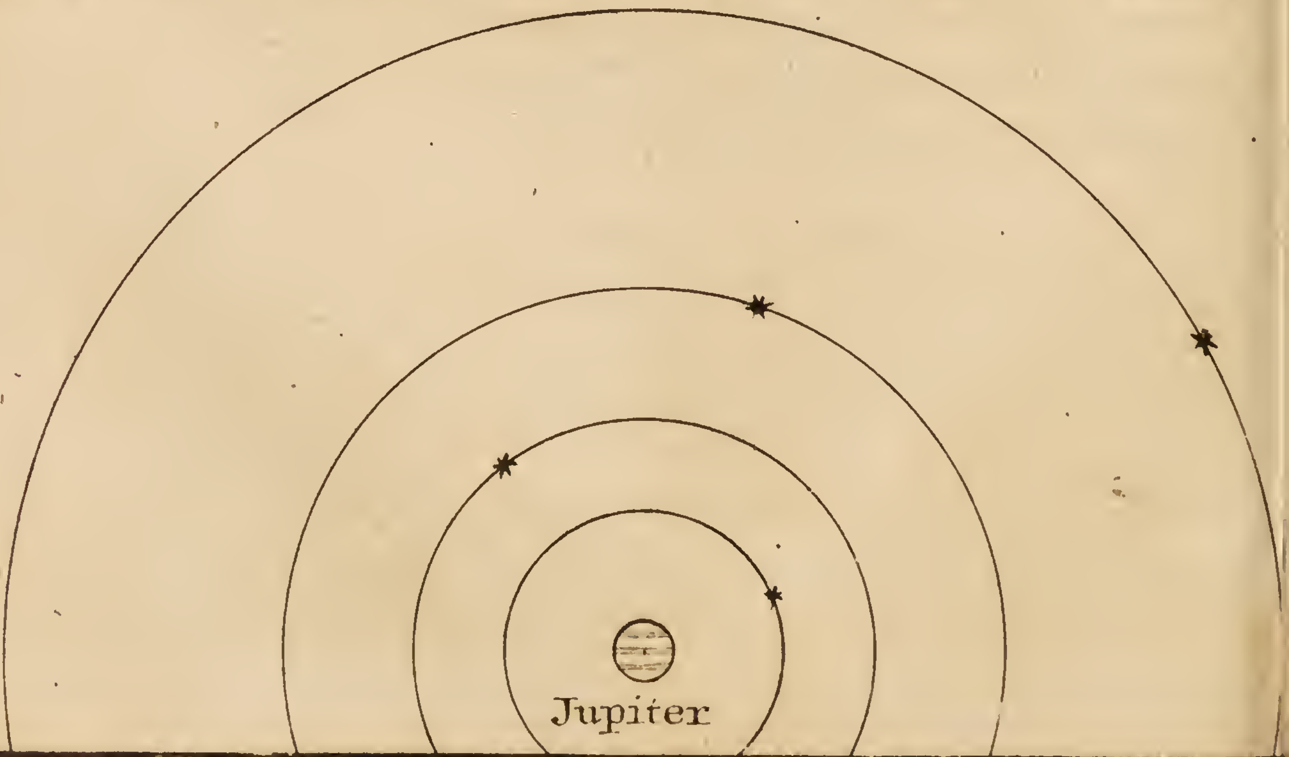
Euphroſ. I ſee her; ſhe is juſt riſen, large, bright, and full faced; pray, fix the Tube at this Window, and we may view her without ſtirring from our Place.

PHASES of the MOON.

Plate XII



JUPITER'S four SATELLITES.



Cleon. I will.——'Tis fixed, and ready: View her various Face.

Euphroſ. I am impatient to peep.—But, Heavens! what do I ſee! a large Map of ſome diſtant World; or rather, an huge terreſtrial Globe! for a Globe it ſeems to be very plainly, and not a flat Surface as it appears to the Eye.—What are thoſe ſpacious ſhining Tracts, thoſe large and obſcure Regions?—Thoſe very bright Spots that ſeem like Stars, ſhining out of the darker Parts,—particularly that remarkable large, round Spot, towards the lower Part of the Orb, which ſhines with a ſteady Luſtre above the Reſt, encircled with a duſky Ring, from which proceed, as it were, Streams or Streaks of Light.——I never before ſaw ſo curious a Picture in the heavenly Bodies, or Landſcape, or what ſhall I call it?—I could feaſt my greedy Eyes 'till Morning with the delightful Proſpect!—Say, *Cleonicus*, does it not look like an inhabited World? Tell me the Opinion of the Philoſophers on this curious Subject.

Cleon. I will.——They judge the Moon to be a Globe like our Earth, inhabited with various Species of Animals, in various Degrees of Perfection. The bright Parts, they ſay, muſt be various Regions of *Land*, ſhining by the reflected Light of the Sun; the dark Parts, *Oceans*, *Seas*, and *Rivers*, which, as they abſorb the Light, muſt needs appear dark. Thoſe bright Spots amid the darker Parts are Iſlands in the Seas, and Mountain Tops, gilded with ſolar Beams. The large round Spot you admired, is a prodigious Mountain, elevating its towering Head from a deep and darkſome Vale ſurrounding it; the bright Streaks are Ridges, and Chains of Mountains, which extend themſelves therefrom towards different Parts, and to vaſt Diſtances.

Euphroſ. Surprizing all! Land and Sea, Mountains and Vales, in the Moon! Wonderous Similitude to our Earth! What would the Poets have ſaid? How beautifully would they have deſcribed this pleaſing Theme, who were ſo laviſh in the Praiſes of *Parnaſſus* and *Helicon*, and *Tempe*'s pleaſant Vale?

Cleon. They would have been proud of ſuch a Subject no Doubt. The Phaſes, and Spots of the Moon, have been thought a Theme not unworthy the Muſes, as appears in the

Strains of ſome of our modern Poets. Of whom, thus Mr. *Brown.*

Regard the Spots which mark the lunar Face,
Her Figure changing in her monthly Race.
A Creſcent now, but feebler Light ſhe yields;
Now half her Diſk her bounteous Brother gilds.
Now riſing in the Eaſt, full-orb'd ſhe glows,
And o'er the Night her ſilver Mantle throws.
The Roughneſs on her broken Edge reveals;
Her Surface maſk'd with Vales, and pointed Hills.
Her brighter Parts, the Sage mountaineous *deems;*
Her darker, Oceans, Seas, *and* ample Streams.

Euphroſ. Well, I give you my Word, *Cleonicus,* if you ſay much more, I ſhall ſcarce forbear wiſhing myſelf there, to view the vaſt Countries; to ſee what Sort of People inhabit them; to obſerve their various Animals, their Trees, and Plants, their Arts and Sciences, their Seaſons and Weather; for all thoſe Things, I preſume, you allow are there as well as here.

Cleon. Moſt Philoſophers do allow it, but ſome deny the dark Parts to be Seas, and ſay they are either Vales and deep Caverns, or elſe Land, of ſuch a Mould as will not reflect Light enough to make it look bright like the Reſt. They alſo deny there is any Atmoſphere, or Body of Air about the Moon, and therefore no Vapours or Rain, *&c.*

Euphroſ. Indeed, *Cleonicus:* Pray, if there be no Air, how do the Inhabitants and Animals live? and if no Rain, how do Trees and Plants grow?

Cleon. I can't tell what Anſwer they would make to ſuch Queries. Sure I am, that Animals and Vegetables like ours, cannot live or grow where there is no Air nor Rain; and therefore they muſt be either different from ours, or none at all; which Suppoſition will make the glorious Orb of the Moon of very little Conſequence to us, and none at all to itſelf; an huge, but uninhabited Wild of barren Hills and gloomy Vales: A Notion of it quite unworthy its Maker.

Euphroſ. The Philoſophers then, I find, are not agreed what Kind of Entertainment the Moon will afford one, and 'till they are, I ſhall wave all Thoughts of going thither. The next Thing I would require of you, is how it comes to paſs, the Moon every Month puts on ſuch a Variety of Faces, appearing now *full*, now *halved*, then *horned*, and not at all when *new?* But I recollect myſelf; you explained theſe Appearances in the Planet *Venus*, and thoſe of the Moon, I preſume, happen after the ſame Manner.

Cleon. They do; but it will be worth while to be a little more particular in explaining the lunar Phaſes. You'll eaſily conceive the Reaſon of them from this little Scheme; where you ſee the large Sun darting forth his Beams, which, at the vaſt Diſtance of the Earth and Moon, fall nearly parallel on them. T is the Earth, and A, B, C, D, E, F, G, H, the Moon in ſeveral Parts of its Orbit circling round it. Here firſt you obſerve, that Half of the Earth and Moon, which is towards the Sun, is wholly enlightened by it, and the other Half, which is turned from it, is totally dark.

Euphroſ. This I apprehend very well, it being evident from the Figure.

Cleon. Conſequently the Moon, when it is in the Poſition A, that is, in *Conjunction*, or exactly between the Earth and Sun, will have all her enlightened Part turned towards the Sun, and all her dark Part towards the Earth; in which Caſe we cannot ſee her, and is therefore ſaid to be a *new Moon.*

Euphroſ. I take you very well; pray go on.

Cleon. When the Moon has gone from A to B, then if that Half, *b a c*, which is turned to the Earth, a ſmall Portion of her Surface is enlightened, as *a b*, and will appear of the Form repreſented at B, in the other Scheme, (*ſee Plate* XIII.) which ſhews you the *Phaſes* of the Moon.

Euphroſ. Very good; and now, *Cleonicus*, I ſuppoſe you ſay the Moon is *horned*, from the Figure ſhe makes; do you not?

Cleon. Yes, my *Euphroſyne*, ſhe is then ſaid to be *horned* or *corniculated*, which is all one; but ſhe becomes gradually leſs and leſs as ſhe approaches to C, in which Situation ſhe is ſaid to be in her *Quadrature*, or Square to the Sun; and then one Half of that Part towards the Earth is enlightened, and appears as at C among the Phaſes. She is now ſaid to be *dichotomized*, *biſected*, or a *Half Moon.*

Euphroſ. And thus when ſhe comes to D, I ſee the greateſt Part of that Half towards us is enlightened, and appears of the ſame Face as at D in this other Scheme; and what Name have you for it then, pray?

Cleon. She is then ſaid to be *gibbous*; and this Phaſe or Aſpect increaſes till ſhe comes to the Situation E, where ſhe is in *Oppoſition* to the Sun, and conſequently turns all her illuminated Surface to the Earth, and ſhines with a *full Face*, as you now behold her; for which Reaſon ſhe is called a *Full Moon.*

Euphroſ. All this I conceive perfectly well from the Schemes; and alſo I ſee that as ſhe paſſes the other Half of her Orbit, from E by F, G, and H to A again, ſhe puts on the ſame Faces as before, but in a contrary Order and Poſition.

Cleon. Very good, Siſter; I ſee you have a right Notion of the Matter, and need nothing further to be ſaid on this Head. I doubt not alſo, but you will eaſily conceive that when ſhe is *new*, and ſeen in the ſame Part of the Heavens with the Sun, ſhe muſt needs riſe and ſet with the Sun; as on the contrary, when ſhe is at E, a full Moon, being exactly in an oppoſite Part of the Heavens to the Sun, ſhe muſt then riſe when the Sun ſets, and ſet when he riſes.

Euphroſ. Yes, this I eaſily underſtand; but am at a Loſs to know the Time of her Riſing and Setting in any other Situation.

Cleon. No Wonder if you are, ſince it is always variable; but this much you may know, that all the while the Moon is paſſing from A by C to E, ſhe is to the *Eaſt* of the Sun, and riſes and ſets after him; but in going from E, by G, to A, ſhe is *Weſt* of the Sun, and riſes and ſets before him: *Always ſhining ſuch a Part of the Night as is proportional to the illuminated Part of her Surface towards us.*

Euphroſ. Dear Brother, I am pleaſed when I can get but a general Idea of Things; to know but ſomething is infinitely more ſatisfactory than abſolute Ignorance.—But the Night is far advanced, pray anſwer me one or two Queſtions more very briefly: Is not that a reflected Light with which the Moon ſhines thus pleaſantly?

Cleon. It is; and therefore ſo exceeding weak and languid, in Compariſon of the Sun's Light, that the greateſt Burning-

Glaſs will not collect enough to make a *ſenſible Warmth.* —— And thoſe who have made the Computation, ſay, the Full-moon Light compared with Day Light is *ninety thouſand Times* leſs than it. Of the full Moon, and her borrowed Light, thus Mr. *Baker.*

When God appoints, the horned Moon renews
Her waining Light, and her whole Viſage ſhews,
Fulfils her Courſe in Circles yet unknown,
And chears Mankind with Luſtre not her own.

Univerſe.

Euphroſ. Chears Mankind indeed! —— But, pray, has not the Moon a very great Influence on the Earth and Plants, and Animals thereon?

Cleon. It would be endleſs to recount all the ſenſeleſs Whimſies that have poſſeſſed the Noddles of the credulous Vulgar, in this Reſpect. *Hudibras* is very witty on this Subject, and very deſervedly.

The Queen of Night, whoſe vaſt Command
Rules all the Sea and half the Land,
And over moiſt and crazy Brains,
In high ſpring Tides, at Mid-night reigns.

Tho' we are not to imagine that becauſe ſome have aſcribed too much Dominion to the Moon, ſhe has none at all; by her Nearneſs to the Earth, ſhe very much affects the Air by the Power of Gravity, and cauſe ſuch Alterations therein as have, doubtleſs, conſiderable Effects thereon, with Reſpect to the Weather at ſundry Times. Alſo, ſhe muſt be allowed to have ſome Influence on the Syſtem of Humours and Juices in the Bodies of Plants and Animals, ſince we find the Ebbing and Flowing of the Sea are certainly the Effects of her Attraction (as we ſhall more particularly conſider hereafter.)

Her deſtin'd Rule, o'er Ocean ſhe preſides,
And pours upon the Shore her lagging Tides.

Univerſe.

Euphroſ. Well, be that as it will, I am not much concerned. ——'Tis ſufficiently late, but the Moon, like a *Mid-night Sun*, invites us with her ſerene and pleaſant Luſtre, yet to reſiſt the Laws of tyrant Nature, and baniſhes Sleep from my Eyes; the Bed is a gloomy Idea. ——I could, methinks, ſpend the whole Night in walking over the pleaſing ſhady Scenes of the Park — but Family Order forbids it.

Cleon. Such a Moon-light Night is extremely delightful indeed! The Poets were ſenſible of this, and have nobly deſcribed the Pleaſures thereof. Thus antient *Homer*,

So when the Moon, refulgent Lamp of Night,
O'er Heav'n's clear Azure ſpreads her ſacred Light;
When not a Breath diſturbs the Deep ſerene,
And not a Cloud o'ercaſts the ſolemn Scene;
Around her Throne the vivid Planets roll,
And Stars unnumber'd gild the glowing Pole.
O'er the dark Trees a yellower Verdure ſhed,
And tip with Silver ev'ry Mountain's Head;
Then ſhine the Vales, the Rocks in Proſpect riſe;
A Flood of Glory burſts from all the Skies;
The conſcious Swains, rejoicing in the Sight,
Eye the blue Vault, and bleſs the uſeful Light.

DIALOGUE II.

Of the MOONS *or* SATELLITES *of* JUPITER *and* SATURN.

Cleonicus.

WELL, *Euphroſyne*, how are you diſpoſed to ſpend this Evening? you ſee 'tis like to be a very fine one.

Euphroſ. You ſeem, *Cleonicus*, to repreſent the Evening as inviting to a Walk; than which nothing will be more agreeable to me, if you are ſo inclined.

Cleon. You know, Siſter, my Inclinations were always to gratify you in every Thing I can.

Euphroſ. You are very good for that indeed, *Cleonicus*; but which Way will a Walk be moſt agreeable? Shall we take a Tour round the Park, or (as we have ſometimes done) over the green Corn Fields to that yonder pleaſant Hill?

Cleon. The Moon will make the Avenues of the Park extremely agreeable; but the Hill will ſuit with our Deſign beſt To-night, which you know was to take a more particular Survey of the Moons which attend *Jupiter* and *Saturn.*

Euphroſ. Let that determine us then; I believe we ſhall have equal Pleaſure in going that Way: Are you ready to walk?

Cleon. I have only the Teleſcope to take, and then I am.

Euphroſ. You are now ready, I ſee.—But as we go forward, pray, *Cleonicus*, give me ſome more particular Account of the Moons, which you ſay attend *Jupiter* and *Saturn?* and alſo the Reaſon why ſome Planets have Moons, and others none?

Cleon. The Planets *Mercury* and *Venus* have no Moons, becauſe they cannot be ſuppoſed to want any in ſuch Vicinity to the Sun; and as to *Mars*, there has been none diſcovered about him, and it is very likely he has none; either becauſe there may be no Inhabitants there, (for he is a ſmall Planet, and of a different Aſpect from all the Reſt) or elſe they may be ſupplied with Light, by Night, ſome other Way; perhaps by a native Luſtre of the Earth, or Soil of that Planet, which may ſhine in the Abſence of the Sun, like ſome natural Phoſphers with us. The *Almighty* can effect the ſame Things by more Ways than one, and generally ſhews his boundleſs Power and Wiſdom by an infinite Variety of Methods.

Euphroſ. Well, it ſeems *Jupiter* and *Saturn* have Moons enough to afford us a Subject of Speculation To-night. Pray, by whom, and how long have they been diſcovered?

Cleon. The Moons or Satellites of *Jupiter* were diſcovered firſt of all by one *Galileo*, a famous *Italian* Philoſopher, who (as himſelf tells us) in the Year 1610, on the 7th of *January*, at Night, ſaw three ſmall bright Stars very near *Jupiter*, two on the Eaſt Side, and one on the Weſt; theſe he took to be fixed Stars at that Time, but happening the next Night to view them again, he ſaw them all three on the Weſt Side of *Jupiter*, which made him greatly wonder how this could be, for it was an Event quite inconſiſtent with the then Theory of the Planets and fixed Stars. On the 10th Night he ſaw but two; and both on the Eaſt of *Jupiter*; on the 11th alſo he ſaw but two, and both on the ſame Side; but one of theſe was twice as large as the other; and thence he was ſure they were not the ſame he ſaw the Night before. On the 13th Night, viewing them again, he ſaw four of theſe ſmall Stars, three on the Weſt Side of *Jupiter*, and one on the Eaſt Side; all nearly in a ſtrait Line. Theſe were all he could ever diſcover, and by conſtantly obſerving their Situation and Changes, found they were not fixed Stars, but Moons, or ſecondary Planets, revolving about *Jupiter*, in the ſame Manner as the primary Planets revolve about the Sun. To theſe he firſt gave the Title of *Medicean Stars*, in Honour of the Family of the *Medici*, who were his Patrons.

Euphroſ. No Doubt but this new Diſcovery was very agreeable News to the Aſtronomers, and gratefully received by them.

Cleon. Surpriſingly ſo; it is not eaſy to imagine with what Eagerneſs they all haſtened to view the new Wonder. *Jupiter* had now more Addreſſes than when he was eſteemed a Deity; every one being willing to ſee the new-diſcovered Equipage and Attendants of this great Lord; 'till at length their Motions became ſo well obſerved, as to be found regular and conſtant, and ſo became reduced to a Theory, as perfect as that of the Moon, or larger Planets.

Euphroſ. Why then, I ſuppoſe, you can tell their Diſtances from *Jupiter*, the Times of their Revolutions about him, &c.

Cleon. Yes, very well. For, by the Theory, the neareſt Satellite to *Jupiter* is diſtant from him about *one hundred eighty-eight thouſand Miles*, and performs its Revolution in *one Day*, 18 *Hours, and* 27 *Minutes.* The ſecond is diſtant from *Jupiter* about *three hundred and twenty thouſand Miles*, and its Period is *three Days*, 13 *Hours, and* 13 *Minutes.* The third Satellite is diſtant about *five hundred and thirty-ſix thouſand Miles*, and its Period is *ſeven Days, three Hours, and* 43 *Minutes.* The fourth, or utmoſt Satellite, is diſtant about *nine hundred and ſeventy-two thouſand Miles*, and its Period is in 16 *Days*, 16 *Hours, and* 32 *Minutes.*

Euphroſ. Then I find that two of thoſe Moons are nearer to *Jupiter* than our Moon is to us; and two of them farther diſtant from him than ours from the Earth.

Cleon. Very true; and at the ſame Time you obſerve, that the periodical Time of our Moon is greater than any of his.

Euphroſ. I do: And now, if you pleaſe, I ſhall be glad to hear the ſame Account of *Saturn*'s Moons.

Cleon. The firſt who obſerved the Satellites of *Saturn*, was Monſieur *Hugens*, who in the Year 1655 diſcovered one, which is the fourth from *Saturn.* But, as I have told you, *Saturn* has five Moons, and all the other four were diſcovered by Signior *Caſſini*, an *Italian*; the third and fifth in the Year 1671, and the two innermoſt in the Year 1686. He called them the *Lodovicean* Stars, in Honour of *Lewis the Great*, in whoſe Reign they were diſcovered.

Euphroſ. And is the Theory of theſe Moons as certain as thoſe of *Jupiter?*

Cleon. They are not ſo eaſily obſerved as *Jupiter*'s, by Reaſon of their great Diſtance from us; but the induſtrious Aſtronomers have found their Diſtance from *Saturn*, and the Time of their Revolutions, as follow:

The firſt Satellite is diſtant from *Saturn* about *eighty-two thouſand Miles*, and his Period is *one Day*, 21 *Hours, and* 18 *Minutes.*

The ſecond is diſtant about *one hundred and ſeventy-five thouſand Miles*, and its Period is *two Days*, 17 *Hours, and* 41 *Minutes.*

The third is diſtant about *two hundred and fifty-four thouſand Miles*, and its Period is in *four Days*, 12 *Hours, and* 25 *Minutes.*

The fourth is diſtant about *ſix hundred and forty-nine thouſand Miles*, and its Period is 15 *Days*, 22 *Hours, and* 41 *Minutes.*

The fifth is diſtant about *nineteen hundred and ſixty-four thouſand Miles*, and its Period is 79 *Days, ſeven Hours, and* 48 *Minutes.*

Euphroſ. Why then I find that ſome of *Saturn*'s Moons are much nearer, and others much farther from him than are thoſe of *Jupiter* from him.

Cleon. They are ſo.[†] And now, Siſter, we are come to the End of our Walk, we will now take a particular View of thoſe Moons with this excellent reflecting Teleſcope, and you will ſee that ſo true is the Theory of theſe *ſecondary Planets*, that thoſe of *Jupiter* will appear ſituated on each Side of him, juſt as I have repreſented them in this little Scheme.

*   *   ○ *   *

Euphroſ. Indeed! Can you predict and deſcribe their Order and Poſition for any given Time ſo exactly, before it comes to paſs? But let me prove you ——

Cleon. You ſhall. See *Jupiter* near South-Weſt —— I'll direct the Teleſcope towards him ——— It is fixed; ſee his Moons ——

Euphroſ. I ſee them plainly as you have repreſented them — Two on the Left Hand, and two on the Right; one of which latter is near to *Jupiter*, the other at the greateſt Diſtance from him —— They appear exceeding plain indeed — and lie very nearly in a ſtrait Line. —— *Jupiter* himſelf ſhines extremely fair and large —— I have loſt Sight of one of the Moons — and the others are going after —— They ſeem to have a quick Motion to the Right, and will ſoon all diſappear. —— Well, they are a pretty Sight, and worthy the Curioſity of any Perſon.—But let me now view the Moons of *Saturn*?

Cleon. *Saturn* you ſee yonder about South-Eaſt, in a very good Situation for our Purpoſe.—I'll turn the Teleſcope about, and direct it to him.—It is now fixed, *Euphroſyne*; ſee *Saturn*, his Ring, and two of his Moons all in View.

Euphroſ. I ſee them — but the Moons are ſo very ſmall, I can but juſt diſcern them — They are both on the Left Hand of the Planet — *Saturn* ſhines very ſerenely — His Ring is a Prodigy never enough to be admired; with this Teleſcope I can plainly ſee the dark Sky between him and the Ring — But he haſtens from my Sight. — I have feaſted my Eyes ſufficiently with

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[†] To give the Reader a better Idea of this Syſtem of *Saturnian Moons*, I have drawn them all out at ſuch Diſtances as they have from the Center of their Primary in the Heavens, together with the proportional Magnitude of *Saturn* and his Ring, in Plate XIV.

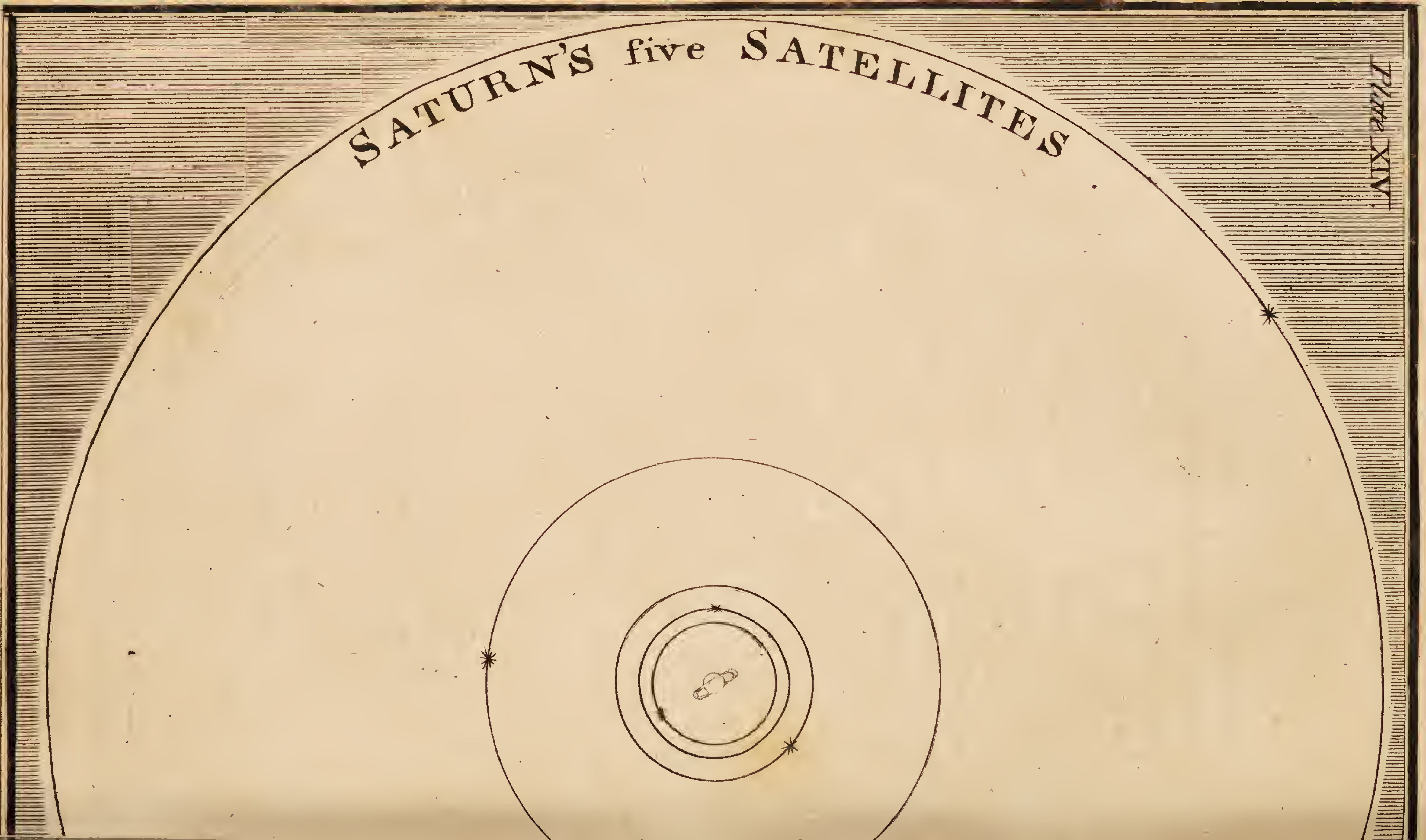


Plate XIV.

SATURN'S five SATELLITES

with the pleaſing Wonders, and wiſh that my Sex in general had the Happineſs of taſting theſe Pleaſures along with me. *Cleonicus*, I thank you; take Care of the Glaſs, and let us now prepare to go home.

Cleon. I am glad you are pleaſed with the Sight you have had of theſe Moons; a better Opportunity could not have offered. But the Air ſeems now cold, and we will return home as you requeſt.

Euphroſ. And let us walk apace; and as we walk anſwer me a few Queſtions concerning theſe Moons: And in the firſt Place, why do thoſe of *Jupiter* appear all in a ſtrait Line, in a Situation Eaſt and Weſt?

Cleon. This is owing to their moving all in ſuch Orbits round their Primaries as lie right before the Eye, and whoſe Planes are nearly in the Plane of the Earth's Orbit; for then Circles will be projected into their Diameters by the Eye, and all Bodies in ſuch Circles will ſeem to move in that right Line.

Euphroſ. I can ſcarce tell what you mean. ———

Cleon. I will explain myſelf by-and-by by Candle-light, and ſhew you how Bodies moving in ſuch Circles as the Moons do, will *appear to move in a ſtrait Line from Eaſt to Weſt*, while they deſcribe *that half Circle which is neareſt to you*; and then to *return back again in the ſame ſtrait Line*, while they paſs through the *remote Half of their Orbits.*

Euphroſ. If this be the Caſe, then each Moon appears to go a certain Diſtance from Eaſt to Weſt, and from Weſt to Eaſt, in each Revolution in its Orbit.

Cleon. Very true; and from thence alſo 'tis evident, that the remoteſt Moon may ſometimes ſeem neareſt to *Jupiter*, and the contrary; ſince the apparent Places of all are conſtantly changing in a direct Line to and from the Bodies of their Primaries.

Euphroſ. I obſerve this Line in which they ſeem to move paſſes through the Center of their Primaries, therefore I ſuppoſe the Moons do ſometimes appear to paſs over the Body of their Primaries; do they not, *Cleonicus?*

Cleon. Yes, Siſter, they do; and then they appear on the Body of their Primaries, ſometimes like *bright Spots*, and ſometimes like *dark ones.*

Eüphroſ. Pray, how can that be?

Cleon. They naturally appear bright by the reflected Light of the Sun, and their appearing dark is owing to ſome very large Spot or Spots on the Hemiſphere next to us, or from ſome Quality of the Surface not apt to reflect the ſolar Light.

Euphroſ. The Moons, I apprehend, paſs over the Body of *Jupiter*, as they paſs from Eaſt to Weſt, or deſcribe the neareſt Half of their Orbits.

Cleon. You apprehend the Matter right; and you will as eaſily conceive, that as they move from Weſt to Eaſt, or deſcribe the remoteſt Semi-circle, they will paſs behind the Body of their Primary, and ſo will be eclipſed from our Sight at that Time.

Euphroſ. I do, *Cleonicus*; and ſhould be glad if I could ſee any of them thus eclipſed. ———

Cleon. I will take an Opportunity one Evening e'er long, to ſhew you ſuch an Eclipſe of theſe Moons, which you muſt know is two-fold: For (1.) the Satellite may be hid from our Sight by the Body of the primary Planet, and this is called an *Occultation* thereof. And (2.) the Satellite may be eclipſed by entering into the Shadow of their Primary, and this is called an *Obſcuration* of thoſe Moons, or moſt properly, an *Eclipſe* of them.

Euphroſ. Why then, ſince the Time of their Revolutions are ſhort, I ſuppoſe that one or other of them muſt frequently diſappear.

Cleon. Very frequently; you often ſee one or more of them miſſing; and Mr. *Molyneux* tells us he viewed *Jupiter A. D.* 1681, *November* 2, at Ten at Night, and obſerved a total Diſappearance of all his Moons at once: *Jupiter*, ſays he jocoſely, appeared ſolitary, and as it were deſerted by his Guards, and a bold *Lucian* might have pulled him headlong from his Throne without Reſiſtance.

Euphroſ. Well, that muſt be a very wonderful Sight, truly. —But our Walk is at an End for To-night, I ſee; and therefore ſhall ſuſpend what I have further to query 'till To-morrow, and thank you for the Pleaſures of this Evening.

Cleon. Such Pleaſures are mutual, I feel them in as large a De-

Degree as you can do, my *Euphroſyne*; which we ſhall now conclude with the following Lines of Sir *Richard Blackmore.*

We've now beheld bright Planetry Jove,
Sublime in Air, thro' his wide Province move;
Four ſecond Planets his Dominion own,
And round him turn, as round the Earth the Moon.
Saturn, *revolving in the higheſt Sphere,*
With ling'ring Labour finiſhes his Year.

DIALOGUE III.

Of the FIXED STARS.

Euphroſyne.

IF you remember, *Cleonicus*, you was ſaying this Morning, that our next Converſation in the philoſophical Way was to be on the Subject of the *fixed Stars.*

Cleonicus. I did, my *Euphroſyne*; for having already conſidered all the moveable Bodies of our mundane Syſtem, we are of Courſe led in the next Place to thoſe which are more remote and immoveably fixed through all the viſible Part of the Univerſe.

Euphroſ. The Stars will afford Matter of moſt agreeable Speculation; I have many Things to aſk concerning them.—See, the Heavens are clear; they begin already to twinkle.—Let us go and take a Walk in the Park to view the ſpangled Canopy.

Cleon. With a very good Will, my *Euphroſyne*; this fine Seaſon is very auſpicious to our Deſigns. The Evening ſeems to invite us abroad, in the Language of Mr. *Baker*,

Come forth, O Man! yon azure Round ſurvey,
And view thoſe Lamps which yield eternal Day.

Bring forth thy Glaſſes; clear thy wond'ring Eyes,
Millions beyond the former Millions riſe:
Look farther:—Millions more blaze from remoter Skies.
Univerſe.

Euphroſ. Exceeding *a propos:* They appear Millions beyond Millions indeed!

Cleon. But don't miſtake, Siſter; the Meaning is, they appear ſo numerous through the Teleſcope, not to the naked Eye.

Euphroſ. Truth, I think they appear ſo to the Eye. Is it poſſible for the Eye to number them over all the Surface of the Heavens?

Cleon. Yes, Siſter; all that are viſible to the Eye have been numbered long ſince over all the ſtarry Vault.

Euphroſ. Surely you joke with me now, *Cleonicus.*

Cleon. Not at all, *Euphroſyne*; the Stars viſible to the naked Eye have been numbered in both the Hemiſpheres, and how many do you think they are?

Euphroſ. How many! Why, ten Thouſand to be ſure, and more.

Cleon. No, no, Siſter; nor yet ſo many Hundreds neither: What do you think of five Hundred at moſt?

Euphroſ. Think! why I think any one may ſee more than five Hundred at one Glance, look which Way you will.—

Cleon. I do not wonder to find you thus miſtaken, and ſurprized at what I tell you. People take it for granted, that becauſe they appear a great many, and ſcattered all over the Sky, that, therefore, they are innumerable; whereas they are not ſo, but are eaſily numbered.

Euphroſ. But give me Leave, *Cleonicus*, I fear you go a Step too far: Does not *Jehovah* tell *Abraham*, that he will make his Seed as the *Stars of Heaven*, as the Sands on the Sea Shore, and as the *Duſt of the Earth*, which can't be numbered?—— Yea the Scripture ſays expreſsly in one Place, that the *Hoſt*, *i. e.* the Stars, of Heaven *cannot be numbered*, Jer. xxxiii. 22. What ſay you to this, *Cleonicus?*

Cleon. Nothing that ſhall reflect on the Holy Scriptures: Only conſider, Siſter, what a mad Piece of Work would it be to inſiſt on the *literal Senſe* of the Scripture in every Place? and our Divines will tell you, that in theſe and ſuch like Places, the Scripture ſpeaks by Way of *Hyperbole*, which is a Figure of Speech very beautifully implying, a *great Number by one infinitely great.*

Euphroſ. Well, in theſe Things I muſt ſubmit to ſuperior Judgment. But ſince you ſay they are numbered, pray who numbered them, and what may their Number be?

Cleon. The antient Philoſopher *Hipparchus*, of *Rhodes*, was the firſt who undertook the arduous Taſk, about 120 Years before Chriſt; *daring*, ſays *Pliny*, *to undertake a Thing, which ſeemed to ſurpaſs the Power of the Gods*, viz. *number the Stars for Poſterity, and reduce them all to Rule.*—His Catalogue contained *one thouſand and twenty-two Stars.*

Ptolemy, the *Egyptian* Aſtronomer, enlarged his Catalogue with only *four Stars.*

After *Ptolemy*, *Ulugh Beighi*, the Grandſon of *Tamerlain* the Great, made a Catalogue of *one thouſand and ſeventeen Stars.*

Next to him the noble *Daniſh* Aſtronomer, *Tycho Brahe*, determined the Places of *ſeven hundred and ſeventy-ſeven Stars*, and reduced them all to a Catalogue.

Kepler produced the next Catalogue, of *one thouſand one hundred and ſixty-three Stars.*

After this *William*, Prince of *Heſſe*, computed the Places of *four hundred Stars*, by the Help of his Mathematicians.

Sometime afterwards the famous Jeſuit, *Ricciolus*, enlarged *Kepler*'s Catalogue to the Number of *one thouſand four hundred and ſixty-eight Stars.*

'Tis alſo ſaid one *Bayerus* made a Catalogue of *one thouſand ſeven hundred and twenty-five Stars.*

After this the famous *Hevelius*, of *Dantzick*, compoſed a new Catalogue, of *one thouſand eight hundred and eighty-eight Stars.*

The late incomparable Aſtronomer Royal, Dr. *Edmund Halley*, undertook a Voyage to the Iſle of St. *Helena*, to obſerve the Stars in the ſouthern Hemiſphere, and at his Return publiſhed a Catalogue of *three hundred and ſeventy-three* of them.

And laſtly, the moſt complete Catalogue of the Stars, was that made and publiſhed by the late Mr. *Flamſted*, in his Celeſtial Hiſtory, which contains about *three thouſand Stars*, which by far the greateſt Part are to be ſeen only with the Teleſcope. And thus you ſee *to count the Stars* is no ſuch new or impracticable Thing.

Euphroſ. I thank you, *Cleonicus*, for this conciſe Hiſtory thereof. What will not the Skill and Induſtry of Men enable them to attain to!

Cleon. You'll further wonder, perhaps, when I tell you, *that there is not the leaſt Star in the Heavens to be ſeen, whoſe Place and Situation is not better known, than the Poſition of many Cities, through which Travellers do daily paſs.*

Euphroſ. That is very wonderful, indeed; but, I preſume, Mr. *Flamſted*'s Catalogue does not contain all the Stars that be in the Univerſe.

Cleon. All! No, nor but a very ſmall Number, in Compariſon of what are unknown and unſeen. The Number of the Stars through all the Extent of univerſal Space is, doubtleſs, infinitely great; but of this no Man can adequately judge.—

Euphroſ. Be the Number of the inviſible Stars as it will, I am ſure thoſe which are viſible give the Heavens a moſt agreeable Aſpect To-night, and brings to my Mind two Lines of Sir *Richard Blackmore.*

With Orbs of Light he inlays all the Spheres,
And ſtuds the ſable Night with Silver Stars.

Cleon. The ſame Poet has another Strain on this Subject, very grand and ſublime.

He ſpreads the pure Cerulean Fields on high,
And arch'd the Chambers of the vaulted Sky;
Which he, to ſuit their Glory with their Height,
Adorn'd with Globes, that reel as drunk with Light;
His Hand directed all the tuneful Spheres,
He turn'd their Orbs, and poliſh'd all the Stars.

Euphroſ. The Stars are, to be ſure, as well a glorious Theme as a beautiful Scene — But why, *Cleonicus*, do ſome Stars appear ſo large, and others ſo very ſmall?

Cleon. Becauſe ſome are very near in Compariſon of others; by common Experience we know, that equal Bodies at unequal Diſtances will appear unequal in Magnitude; thoſe which are neareſt appearing largeſt.

Euphroſ. Can you tell any Thing certain about the Diſtance of the Stars?

Cleon. No; the Diſtance of the neareſt fixed Star is immeaſurably great.——

Euphroſ. Can you make no Computation or Gueſs in any wiſe probable?

Cleon. Scarcely that: Mr. *Huygans* tell us, that the Dog-Star (which is the largeſt, and conſequently the neareſt) appears *twenty-ſeven thouſand, ſix hundred and ſixty Times* leſs than the Sun, and therefore muſt be above *two Millions of Millions* of Miles from us.

Euphroſ. Stupendous Diſtance!——

Cleon. So great, that a Cannon-ball would ſpend near *ſeven hundred thouſand Years* in flying thither, with the ſame Velocity it has at the Cannon's Mouth.

Euphroſ. Amazing! But, pray, muſt not thoſe Bodies be very large to be viſible at ſuch an immenſe Diſtance?

Cleon. Yes, immenſely large indeed; and not only ſo, but they muſt alſo ſhine with their own native Light, or elſe they could never be viſible to us at ſuch a Diſtance.

Euphroſ. Indeed! Why what will you make of the Stars at this Rate of conſidering them? I believe People in general look upon them only as twinkling Points, to make the Night pleaſant.——

Cleon. This vulgar Notion of the Stars is very poor and low, and utterly unworthy ſo grand and glorious a Part of viſible Nature. The Poet elegantly reproves and derides the Ignorance and Stupidity of ſuch as think the Stars were appointed to ſerve ſuch mean Purpoſes, in the following Lines.

And can'ſt thou think, poor Worm! thoſe Orbs of Light,
In Size immenſe, in Number infinite,
Were made for thee alone, to twinkle to thy Sight?
Preſumptuous Mortal! can thy Nerves deſcry,
How far from thee they roll, from thee how high?

With all thy boaſted Knowledge can'ſt thou ſee
Their various Beauty, Order, Harmony?
If not — then ſure they were not made for thee.

And a little after;

Correct thy aukward Pride, be wiſe, and know,
Thoſe glitt'ring Specks thou ſcarce diſcern'ſt below,
Are Founts of Day, ſtupendous Orbs of Light,
Thus by their Diſtance leſſen'd to the Sight.

UNIVERSE.

Euphroſ. One would take a Star, according to theſe Deſcriptions, to be in itſelf ſomewhat like our Sun. ——

Cleon. You have juſt hit upon the Matter, my *Euphroſyne*; they are by all the modern thinking Philoſophers judged to be ſo many Suns, having their ſeveral Syſtems of Planets circling about them, though by Reaſon of their Smallneſs they cannot be ſeen.

Euphroſ. Then, according to this Doctrine, the Univerſe muſt be filled with ſolar Syſtems, which, if they bear any Analogy to ours, muſt make a glorious Harmony in the grand Compoſition of Nature; and is ſuch a noble and auguſt Idea of the World, as I never ſhould have conceived or thought of, nor can enough admire!

Cleon. This new and noble Notion of the Univerſe has fired the Muſes themſelves, and ſet the Poets in Emulation who ſhould ſing the lofty Theme in the moſt exalted Strains. Thus one,

Now if thou can'ſt the mighty Thought ſuſtain,
If it not akes thy Soul, and racks thy Brain,
Conceive each STAR *thou ſeeſt another* SUN,
In Bulk and Form, and Subſtance like thine own.

And a little below;

Conſult with Reaſon, Reaſon will reply,
Each lucid Point which glows in yonder Sky,

Informs a Syſtem in the boundleſs Space,
And fills with Glory its appointed Place:
With Beams unborrow'd brightens other Skies,
And Worlds, to thee unknown, with Heat and Life ſupplies.
UNIVERSE.

Thus another ſings;

Now to freſh Wonders, let thy Search remove;
Seeſt thou thoſe Orbs that numerous roll above:
Thoſe Lamps that rightly greet thy viſual Pow'rs,
Are each a bright capacious Sun, like ours.
The Teleſcopic Tube will ſtill deſcry
Myriads behind, that 'ſcape the naked Eye.
And farther on, a new Diſcovery trace,
Thro' the deep Circle of encompaſs'd Space,
How thick (diſcernable to aided Sight)
Their Conſtellations crowd the milky Height,
Whoſe Sphere elude the Reach of naked Eyes,
And ſeem with Light to belt whiten'd Skies.
If each bright Star ſo many Suns are found,
With Planetary Syſtems circled round,
What vaſt Infinitude of Worlds may grace,
What Beings people the ſtupendous Space?
Whatever Race poſſeſs th' ethereal Plain,
What Orbs they people, or what Ranks maintain?
Tho' the deep Secret Heav'n conceal below,
One Truth of univerſal Scope we know.
Our nobler Part, the ſame ethereal Mind,
Relates our Earth to all their reaſoning Kind.
One Deity, one ſole creating Cauſe,
Our active Cares, and joint Devotion draws.

And again:

Thus has the Muſe, but with a tranſient View,
Roam'd the wide Circuit of our Syſtem through;
But Millions more the Pow'r divine has plac'd,
Millions of Suns with circling Planets grac'd,

Suns large as ours, yet to th' unaided Sight,
Points ſcarce diſtinguiſh'd in the Train of Night.
The Ball which ſwiftly from the Cannon flies,
Piercing with equal Speed the yielding Skies,
Amazing Thought! ſeven hundred thouſand Years
Muſt travel e'er it reach theſe diſtant Spheres.

Euphroſ. Theſe Gentlemen deſcant very finely, indeed, on the wonderful Subject; but as it is of ſuch vaſt Importance to the forming a right Idea of Nature, I ſhould be glad to hear you rehearſe particularly the Arguments on which this Doctrine of *Solar Stars* is founded.

Cleon. I will briefly recite to you the principal, which are as follow:

Firſt. They all ſhine by their own native Light, which is the Property of a Sun only.

Secondly. They are of a vaſt Magnitude, like our Sun; or elſe they could not be ſeen at ſuch an immenſe Diſtance.

Thirdly. They are placed at an almoſt infinite Diſtance from each other, as far at leaſt as our Sun is from them.

Fourthly. Were we removed to the Diſtance of the neareſt Star, our Sun would appear no bigger than a Star, and would appear as ſuch among the reſt.

Fifthly. At the Diſtance of the Stars our Syſtem of Planets would be inviſible, even *Jupiter* himſelf, by Reaſon of their Smallneſs, and feeble reflected Light.

Sixthly. God made nothing in vain, therefore not the Stars, which conſtitute almoſt the whole Univerſe; but they anſwer ſome great and glorious Purpoſe unknown to us.

Seventhly. The Obſervation of *new Stars*, which are ſuppoſed to be the Suns of ſome new-created Syſtems; thus our Sun at the *Moſaic* Creation might appear as a *new Star* to others.

Eighthly. Some Stars have decayed, and become quite extinguiſhed, which probably were the Suns of old Syſtems, which had ſtood their appointed Time. A Change which our Sun will probably undergo in Time.

Ninthly. The Scripture ſpeaks of a *Plurality of Worlds*; and it is not probable God would make but *one Syſtem*, whoſe utmoſt

moſt Extent is but a Point compared with the Univerſe.—— From theſe, and ſuch like Methods of Reaſoning, it is at leaſt very probable that each *fixed Star* is a *Sun*, which is the Center of a Syſtem of circulating Planets of ſeveral Kinds, and that theſe Planetary Orbs are inhabited by Creatures of various Sorts and Degrees of Perfection. — This is agreeable to what we obſerve in our Earth and Syſtem; accordingly Mr. *Baker*,

Heed well this Orb, where Fate has fix'd thy Lot;
Seeſt thou one uſeleſs, or one empty Spot?
Obſerve the Air, the Waters, and the Earth,
Each Moment give ten thouſand Creatures Birth.
Here ev'ry Place, ſo far from lying waſte,
With Life is crouded, and with Beauty grac'd;
Nor can thoſe other Worlds, unknown by thee,
Leſs ſtor'd with Creatures, or with Beauty be;
For God is uniform in all his Ways,
And every where his boundleſs Pow'r diſplays;
His Goodneſs fills immenſurable Space,
Reſtrain'd by Time, nor limited to Place:
His Wiſdom form'd great Nature's mighty Frame,
And rules by Laws eternally the ſame.

UNIVERSE.

Euphroſ. I think the Reaſons you alledge make it ſufficiently probable to induce any one to believe a *Plurality of Worlds.*— But we have walk'd 'till the Evening is cold, and the Graſs very dewy; and tho' I have many more Things to enquire about the Stars, I will, if you chuſe it, *Cleonicus*, refer them 'till the next fine Evening, when I ſhall be glad to have a View of ſome of them with the Teleſcope.

Cleon. That you ſhall, my *Euphroſyne*; for beſides that 'tis late, we are prevented any Thing of that Kind To-night by the Clouds coming on, and the Weather growing up, which Circumſtance is aptly expreſſed by Sir *Richard Blackmore.*

His marſhall'd Clouds which intercept the Light,
Seal up the Stars, the twinkling Eyes of Night.

DIALOGUE IV.

The Speculation *of the* STARS *continued.*

Euphroſyne.

AFTER a few tempeſtuous Nights, I ſee the Heavens begin to refine, and the azure Expanſe renews its ſparkling Glory. We will, therefore, now re-aſſume our Speculation of the Stars, if you pleaſe, *Cleonicus*, and conſider divers other Circumſtances, of which I have not yet a good Notion.

Cleon. You engage me with a great deal of Pleaſure, *Euphroſyne*; I ſhall gladly impart to you all that I know concerning the Stars.

Euphroſ. The next Queſtion then that I would aſk is, whence comes it to paſs that *each Star twinkles ſo vehemently in a clear Night?*

Cleon. The *Twinkling*, or *Scintillation* of the Stars ariſes from the continual Agitation of the Air, or Atmoſphere, thro' which we view them; for the Particles of the Air are always in Motion, and will cauſe a Twinkling in any diſtant luminous Body, which ſhines with a very ſtrong Light. I ſay, *a very ſtrong Light*, and *a diſtant Object*; becauſe *near* Objects, as *a Candle*, or a *feeble Light*, as of *the Planets*, will produce no ſuch Appearance.

Euphroſ. Then none of the Planets twinkle in the darkeſt Night, do they?

Cleon. No; and by that you may diſtinguiſh them at any Time from the fixed Stars; nor will the Stars twinkle, if you view them through a very ſmall Hole in a Piece of Paper, or thro' a Teleſcope.

Euphroſ. Pray, let me try that.

Cleon. You ſhall; take this Teleſcope, and look at yon ſparkling Star.——

Euphroſ. I ſee which you mean, give me the Glaſs——I ſee it plainly—It appears very ſteady, nor does it ſparkle at all—yet it appears with a very ſtrong Light—But this Teleſcope does not magnify much, I believe, for I can't perceive that the Star is bigger than it appears without it.——

Cleon. That is not the Fault of the Glaſs, it magnifies very much; but were it to magnify a hundred Times more, or a thouſand, the Star would ſtill appear but as a Point; for by Reaſon of its immenſe Diſtance, it eludes the Force of any magnifying Glaſs. Yea, on the contrary, the Stars are rather diminiſhed in Appearance, by taking off their ſparkling Luſtre.

Euphroſ. Well, then, the next Thing I would enquire is, why they are called *Fixed Stars?*

Cleon. Becauſe they do not, like the Planets, change their Places, or alter their Situations in the Heavens, but keep at all Times the ſame Diſtances and Poſition among themſelves; that is, the ſame Star, at the ſame Time of the Year, always is ſeen in the ſame Place, and at the ſame Diſtance from others about it.

Euphroſ. I know you'll reſolve the apparent *nocturnal Motion of the Stars*, from Eaſt to Weſt, into a Conſequence of the *diurnal Motion of the Earth* the contrary Way; but how happens it that at one Time of the Year we ſee one Set of Stars in the Sky, and at another Time of the Year another?

Cleon. This ariſes from the annual Motion of the Earth, and which I will explain to you by this little Scheme; where S is the Sun, and A B C D the Earth, in four Poſitions of its Orbit; alſo E F G H the Firmament of the Stars, at an infinite Diſtance.

Now the Earth in each Situation appears half enlightened, and half dark, repreſenting Day and Night.—And when it is at A, the Sun will appear at Noon in the Heavens at G, and will obſcure all the Stars in the Hemiſphere, F G H; whereas at Midnight the Point of the Heavens E, will be in the Meridian, and then all the Stars in the other Hemiſphere, F E H, will be viſible. Do you apprehend me?

Euphroſ. Yes, pretty well; pray proceed.

Cleon. Then when the Earth, three Months after, is come to the Situation B, the Sun at Noon will be ſeen at H, and all the Heavens, G H E, will be Day; and over all the other Half, E F G, the Stars will glitter at Night.

Euphroſ. Then I perceive the Stars in the Quarter F G, will now be viſible, which (in the former Poſition) were not; and thoſe in the Quarter H E, will become obſcured by Day-light.

Cleon. You conceive the Thing admirably well, my *Euphroſyne:* In like Manner when the Earth is at C, the Heavens, H E F, will be Day, and F G H Night, where all the Stars will ſhine.

Euphroſ. Then that Part of the Heavens which was Day when the Earth was at A is now Night, and ſo the Stars which were all then inviſible are now viſible, and the contrary.

Cleon. Very right, Siſter, that is the Caſe; and laſtly, when the Earth is at H, the Stars in the Hemiſphere, E F G, will be obſcured by Day-light, and thoſe in G H E will all be viſible in the Night.

Euphroſ. Well, I am fully ſatisfied in this Point, *Cleonicus;* but why do I ſee ſome Stars conſtantly all the Year round, and others but at different Times and Seaſons?

Cleon. You might have added too—and *ſome Stars not at all.* But as this depends on ſome Underſtanding of the *Doctrine of the Sphere*, you will apprehend it much better when I ſhall one Day or other explain to you the *Uſe of the Celeſtial Globe.*

Euphroſ. I am willing to wait all proper Opportunities, and am obliged to you for chooſing them. And now I ſuppoſe there remains nothing beſides relating to the Motion of the Stars to be conſidered; therefore ———

Cleon. Hold, Siſter, before we leave this Subject, I ſhall juſt obſerve to you, that there is only one Star in all the viſible Heavens which ſeems to have no Motion at all.

Euphroſ. Indeed! Pray, which is that?

Cleon. It is that commonly called the *North Pole*, or more properly the *Polar Star.*

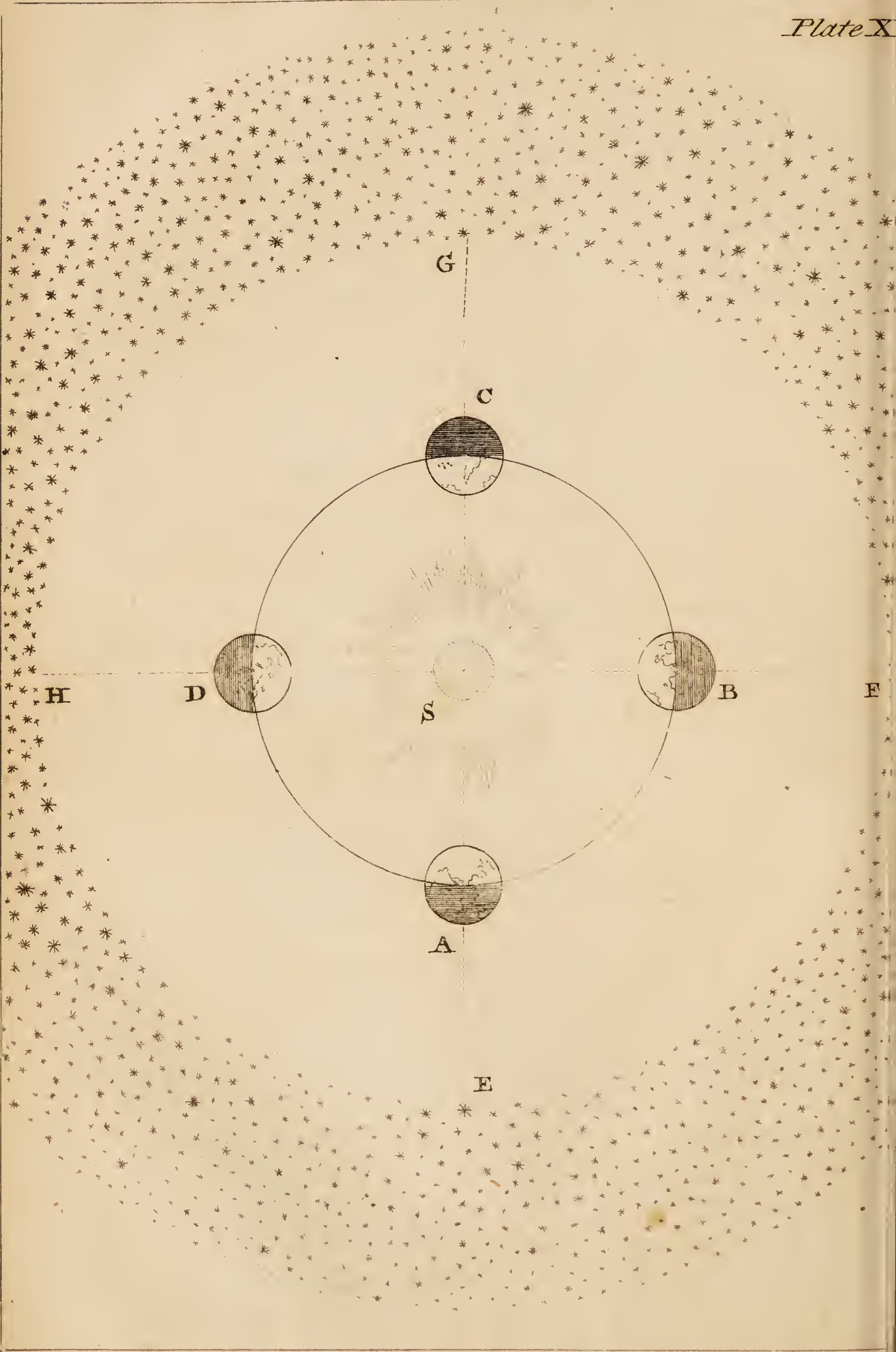
Euphroſ. Be ſo good as to ſhew it to me.

Cleon. It is that ſmall, but bright Star, which you ſee yonder, full North, amidſt many other, but ſmaller Stars; it is ever pointed to by thoſe two large bright Stars in *Charles's Wain*, which you obſerve a little to the Left Hand.

Euphroſ. I ſee the Star you mean, very plainly; and do you ſay it has no Motion?

Cleon. It does not appear to move either with the *diurnal* or *annual Motion*, as all the other viſible Stars do; but view it at what Time of the Night or Year you will, you ſee it always in the ſame Place.

The Apparent Annual motion *of the* STARS.



Euphroſ. But you ſeem to intimate by your Way of ſpeaking, that it has ſome Sort of Motion or other; has it not?

Cleon. It has; but ſuch an one as is not ſenſible in a long Courſe of Years, and ariſes from a Cauſe that you muſt ſtay a while before you can well underſtand it.

Euphroſ. To what End then do you mention it to me, *Cleonicus?*

Cleon. Becauſe there is ſomething very ſurpriſing in the Conſequence thereof: For this Star, though it be now very nearly in the North Point of the World, has ſuch a Motion round a certain Point in the Heavens, as will in Time make it to circulate through the ſeveral Parts of the Heavens like other Stars.

Euphroſ. Say you ſo; will the *North Star* in Time be ſeen *Southward* of us? Pray, in how long a Time?

Cleon. In the Space of *twelve Thouſand nine Hundred and ſixty Years*; for in double that Time, *viz.* in twenty-five Thouſand nine Hundred and twenty Years, it makes one Revolution, which is called the *Great*, or *Platonic Year*, from *Plato* the Philoſopher, who, with other of the Antients, ſuppoſed that after this Period all worldly Changes would return in the ſame Manner and Order as before.

Euphroſ. Is this a *real*, or only an *apparent Motion* of the Stars?

Cleon. Apparent only, as are both the other. And thus much of the *Motion of the Stars*, of which *Dryden* has theſe Lines,

As when the Stars in their ethereal Race,
At Length have roll'd around the Liquid Space,
At certain Periods they reſume their Place.
From the ſame Point of Heav'n their Courſe advance,
And move in Meaſures of their former Dance.

Euphroſ. I obſerve a manifeſt *Difference in the Colour* of the Stars, ſome look *red*, others *pale*; pray, what can be the Meaning of that?

Cleon. You aſk a Queſtion I can't reſolve.—There is ſomewhat undoubtedly very different in the Nature both of the Matter and Light of thoſe Stars or Suns; but what that is, their Maker only knows.

Euphroſ. I have had my Eye ſome Time upon a Kind of *brightiſh miſty Spot*, which at firſt Glance ſeems like a Star; pray, is it a Star, or what is it?

Cleon. I ſee what you mean; it is indeed called a *nebulous*, or *miſty Star*; but it is not a Star properly ſpeaking: You'll have a better Notion of it when you view it with the Teleſcope.

Euphroſ. Give me the Tube, and I'll view it — Bleſs me, what do I ſee!—The Glaſs is covered with Stars as thick as Bees in a Swarm.—Very ſmall Stars, yet very diſtinct.—I do ſee now what it is, indeed—A compound Star, conſiſting of Multitudes of ſingle ones.—Well, this is a wonderful Sight, on my Word, *Cleonicus*.

Cleon. There is nothing more curious among the Stars, in my Opinion. There are reckoned about ſix or ſeven of theſe *nebulous Stars* in the Heavens; in ſome of which there appears a bright, lucid Part, in which ſome Stars appear, as from a white Cloud, and theſe are reckoned to be Regions of a peculiar Nature, which enjoy a native Light, and an uninterrupted everlaſting Day.

Euphroſ. How infinitely various, amazing, and unaccountable are the Works of Nature! But caſting my Eyes on the ſeven Stars, puts me in Mind to aſk a Queſtion I have long intended; and that is, Why are they called the *ſeven Stars*, when no Perſon, I believe, can tell above ſix?

Cleon. In Anſwer to this, I ſhall at preſent only ſay, that in former Times, 'tis probable, there were *ſeven* to be ſeen, one of which afterwards became extinct, and was never more ſeen; and that as long ſince as *Ovid*'s Days, (who lived in the Time of our Saviour) as is evident by theſe Verſes in his *Faſti*.

> *Now riſe the* Pleiades, *thoſe Nymphs ſo fair,*
> *Once ſeven number'd, now but ſix there are.*

Now though there appear but ſix Stars in this Conſtellation to the naked Eye, yet take the Teleſcope and view them, and you will diſcover many more.

Euphroſ. Pray, give it me then; I'll view them.—O ſurprizing!—What a Number do I ſee! I can tell near twenty.—They fill a greater Space than the Glaſs will take in.—Some are very large, others ſmall.—There are ſo many, I can't number them all.

Cleon. I believe ſo, *Euphroſyne*; for Dr. *Hook* tells us, that with a twelve Foot Tube he counted no leſs than 78 Stars; and making Uſe of longer Teleſcopes he diſcovered ſtill many more. But that the Univerſe abounds with numberleſs Numbers of Stars, you will ſoon be convinced, by directing the Teleſcope to any Part of that whitiſh Tract of the Heavens we call the *Galaxy*, or *Milky Way*.

Euphroſ. That I'll inſtantly do.—I ſee them, innumerable!—They fill the Glaſs, like the nebulous Star.—If I turn the Tube this Way or that, ſtill nothing but Stars are ſeen—Moſt of them very ſmall, ſome ſcarce diſcernable.—The Region of Heaven looks light through all this Part.—Sure we have here a larger Proſpect into the Univerſe.

Cleon. This Part of the Heavens being illuminated by the Luſtre of ſuch an Infinity of Stars, gave Occaſion to the Heathen Poets to make it the *high Road to Heaven*, or *to the Court of Jove*. Thus *Ovid*;

> *A Way there is in Heav'n's extended Plain,*
> *Which when the Skies are clear is ſeen below,*
> *And Mortals by the Name of* Milky *know:*
> *The Ground-work is of Stars, thro' which the Road*
> *Lies open to the Thunderer's Abode.*

And our famous *Milton*;

> *A broad and ample Road, whoſe Duſt is Gold,*
> *And Pavement Stars, as Stars to us appear,*
> *Seen in the* Galaxy, *that* Milky Way,
> *Like to a circling Zone, powder'd with Stars.*

Again; the aſtronomical Poet *Manilius*, ſpeaking of the *Galaxy*, has theſe Lines;

> *Nor need we with a prying Eye ſurvey*
> *The diſtant Skies, to find the Milky Way,*

It muſt be ſeen by all, for every Night
It forcibly intrudes upon our Sight,
And will be mark'd, for ſhining Streaks adorn
The Skies as opening to let forth the Morn.
And as a beaten Path that ſpreads between
A trodden Meadow, and divides the Green:
Or as when Seas are plow'd, behind the Ship
Foam curls on the green Surface of the Deep;
In Heav'n's dark Surface ſuch this Circle lies,
And parts with various Light the azure Skies.
Or as when Iris *draws her radiant Bow,*
Such ſeems this Circle to the World below.
It all ſurpriſeth, our inquiring Sight
It upward draws, when through the Shades of Night
It ſpreads its Rays, and darts amazing Light.

LIB. I.

Euphroſ. But why, *Cleonicus*, is this Part of the Heavens ſtored with ſuch Myriads of Stars more than any other Part?

Cleon. I cannot tell the Reaſon, but ſo it is; and hence it is that in this Part, oftener than in any other, we find the *Extinction of old Stars*, and the *Appearance of new ones.*

Euphroſ. I ſhould be glad to have a ſhort Account of theſe old and new Stars that you ſpeak of, having never heard any Thing on that Subject.

Cleon. Hipparchus, who lived ſome Years before Chriſt, is ſaid to be the firſt who ſaw or obſerved a new Star. After many Ages, in the Year 1572, a new Star appeared to *Corn. Gemma*, and *Tycho Brahe*, and became extinct in the Year 1574. It broke out with the Luſtre of *Venus*, and decayed very gradually all the Time. Such another was ſeen in 1604, and died away gradually in about the ſame Time. In the Year 1696, one *Fabricius* diſcovered the *Stella Mira*, or wonderful Star, in the *Neck of the Whale*, which is found to appear and diſappear periodically, its Period being ſeven Revolutions in ſix Years. In the Year 1600, *Wm. Janſonius* diſcovered another in the *Neck of the Swan*, which has ſince appeared of different Magnitudes, and is now very ſmall. Another was diſcovered in the Year 1670, by *Hevelius*, and diſappeared in 1672. And in the

Year 1686, the laſt new Star was diſcovered by Mr. *G. Kirch*, which returns periodically in the Space of about 404½ Days; and theſe are all the fixed Stars which have altered their Appearance for 160 Years paſt.

Euphroſ. Dear *Cleonicus*, I am obliged to you; but fear I tire you with my Impertinencies: 'Tis late, and I'll have done, if you'll only tell me what I am to underſtand by the Star which I ſaw this Moment ſhoot along a good Part of the Heavens.

Cleon. It was not a Star that you ſaw, my *Euphroſyne*, but only a fiery Meteor kindled in the Air, and then looked like a Star; and as all ſuch Bodies move ſwiftly, like a *Sky-Rocket*, while they ſpend themſelves, ſo this *Meteor* ſeemed like a ſhooting or *falling Star*, till it became extinguiſhed; according to the Poet.

Thus oft before tempeſtuous Winds ariſe,
The ſeeming Stars fall headlong from the Skies,
And ſhooting thro' the Darkneſs, gild the Night
With ſweeping Glories, and long Trails of Light.
DRYDEN'S VIRGIL.

Thus alſo *Manilius*;

But ſtill, when wand'ring Stars adorn the Night,
The falling Meteors *draw long Trains of Light*;
Like Arrows ſhot from the celeſtial Bow,
They cut the Air, and ſtrike our Eyes below.
LIB. I.

DIALOGUE V.

Of an ECLIPSE *of the* SUN.

Euphroſyne.

I Have been very anxious about the Weather To-day, how it might chance to fall out, on Account of the Eclipſe of the Sun that is to be this Afternoon; but it is at preſent fine, and

I hope the Clouds will forbear, and permit us the extraordinary Sight, eſpecially now you are here.

Cleon. I believe it will be a fine Day throughout: It will begin juſt at 39½ Minutes after Three o'Clock, againſt which Time I will get the Teleſcope and darkened Chamber in Readineſs for the Obſervation.

Euphroſ. What I have often wondered at, *Cleonicus*, is, how any Body can tell when an Eclipſe will happen ſo long beforehand, and to ſuch Exactneſs of Time.

Cleon. It does ſeem wonderful to thoſe who know not the Principles they go upon; but I do aſſure you, my *Euphroſyne*, the Aſtronomer can foreknow and predict the Time of an Eclipſe to a Minute, with the ſame Eaſe, and in the ſame Time as you can raiſe a Mince-Pye.

Euphroſ. Indeed! Well, that old Saying is good, *All Things are eaſy when underſtood.* But, pray, what is the Meaning of the Word *Eclipſe?*

Cleon. The very Nature of the Thing is implied in the Word, which is of *Greek* Original, and ſignifies a *Defect* or *Deficiency*; and therefore is properly applied to expreſs the *Loſs of Light* in the *Sun* or *Moon*. The Word *Eclipſe* alſo ſignified to *faint*, *ſwoon*, or *be ſick*; and was generally applied to People when in a *fainting Fit*, or *dying away*; and the ancient ignorant Heathens, thinking this to be the Caſe with the Sun and Moon at ſuch Times, uſed to ſay they were *eclipſed*. Thus *Lucretius*;

Eclipſes may be ſolv'd a thouſand Ways,
For if the Moon can ſtop deſcending Rays
By thruſting her dark Self between, and ſo
Bring ſudden Shade, and Night on all below;
Then give me Reaſons why there cannot be
Another Thing, too dark for us to ſee,
And fit to ſtop the Rays, as well as ſhe?
Or, why the circling Sun, in paſſing by
Some venomous Places of the neighbouring Sky,
May not grow ſick, and pale, and almoſt die?
Thoſe paſt, grow well, regain his former Light?
Thus ſometime make us Day, and ſometime Night.

Thus *Virgil* alſo in his Petition to the Muſes;

Give me the Ways of wand'ring Stars to know,
The Depths of Heav'n above, and Earth below;
Teach me the various Labours of the Moon,
And whence proceed th' Eclipſes of the Sun.
GEORG. II.

Euphroſ. I could heartily join with *Virgil* in his Prayer, but I am afraid my Stars never deſigned me for an Aſtronomer good enough to underſtand the Nature of Eclipſes.

Cleon. Don't think ill of your Stars till you know you have Reaſon; I believe there are few Ladies who have not Intellects ſufficient to underſtand the general Doctrine of Eclipſes, eſpecially as to the Manner of them, without the mathematical Principles, on which the Theory depends.

Euphroſ. I ſhall be glad if I can be an Inſtance of this to the reſt; I preſume you muſt go to Scheming again, if you intend I ſhould underſtand any Thing of the Matter.

Cleon. Without Figures, or Schemes, none can underſtand it; but with thoſe Helps they eaſily may. See here a little Draught of an *Eclipſe of the Sun and Moon.*

Euphroſ. I do; and can aſſure you that it appears at firſt Sight ſo eaſy and expreſſive, that I am in Hopes I ſhall give you but little Trouble in the Explication. I ſee the Earth in its Orbit about the Sun, and the Moon in two Poſitions in her Orbit about the Earth; in the firſt, ſhe is between the Earth and Sun, and caſts her Shadow upon the Earth; in the latter, ſhe is involved in the Shadow of the Earth, which is then interpoſed between her and the Sun.

Cleon. You conceive a very good Notion of the Thing in general, and a few Particulars explained will give you a good Idea of both Kinds of Eclipſes. And firſt, for an *Eclipſe of the Sun*, you ſee that is occaſioned by the *New Moon* coming between the Earth and Sun, by which Means her Shadow often falls upon the Earth in ſome Part, as at C; for to an Inhabitant at C, the Moon will appear to cover the whole Face of the Sun very nearly, and ſo cauſe what we call a *total Eclipſe of the Sun.*

This is evident by drawing the Lines CMD and COE, from an Eye at C, touching the two extreme Parts of the Moon, M and O; for thoſe Lines continued to the Sun will very nearly include his whole Body, as you ſee; and conſequently it can't be ſeen by the Eye at C.

Euphroſ. I underſtand you pretty well as to that; but you ſeem to intimate that the Moon does not wholly and entirely eclipſe the Sun's Body, when ſhe is directly between us and him.

Cleon. No, ſhe does not always; becauſe her apparent Face or Diſk is ſomewhat leſs than the apparent Face of the Sun, the Proportion being about 31 to 32; and therefore in the greateſt Eclipſe of the Sun, there will be ſome Time a very ſmall *Annulus*, or Ring, on the Sun's Extremity not eclipſed, but viſible, as you will by and by ſee.

Euphroſ. Beſides the dark Shadow MCO, there is a fainter Sort of Shadow AMOB; pray, what am I to underſtand by that?

Cleon. That is called the *Penumbra*, or *partial Shadow*, becauſe a Perſon any where on the Earth's Surface between C and A will ſee only a Part of the Sun's Face eclipſed; but ſo much a greater Part as he is nearer to C, or a leſs Part as he is nearer to A; for 'tis manifeſt when the Spectator is at A, he will ſee no Eclipſe at all, but the whole Face of the Sun will there be viſible, ſince the Line AME touches the Extremities of the Moon and Sun that are next to each other.

Euphroſ. I apprehend you very well; for ſince in any Part between C and A there will be more or leſs of the Sun's Light, the Shadow ariſing from the eclipſed Part will not be ſo dark as at C, where there is no Light, or next to none; and the ſame I ſee will happen all around the dark Shadow to the Diſtance of CA or CB.

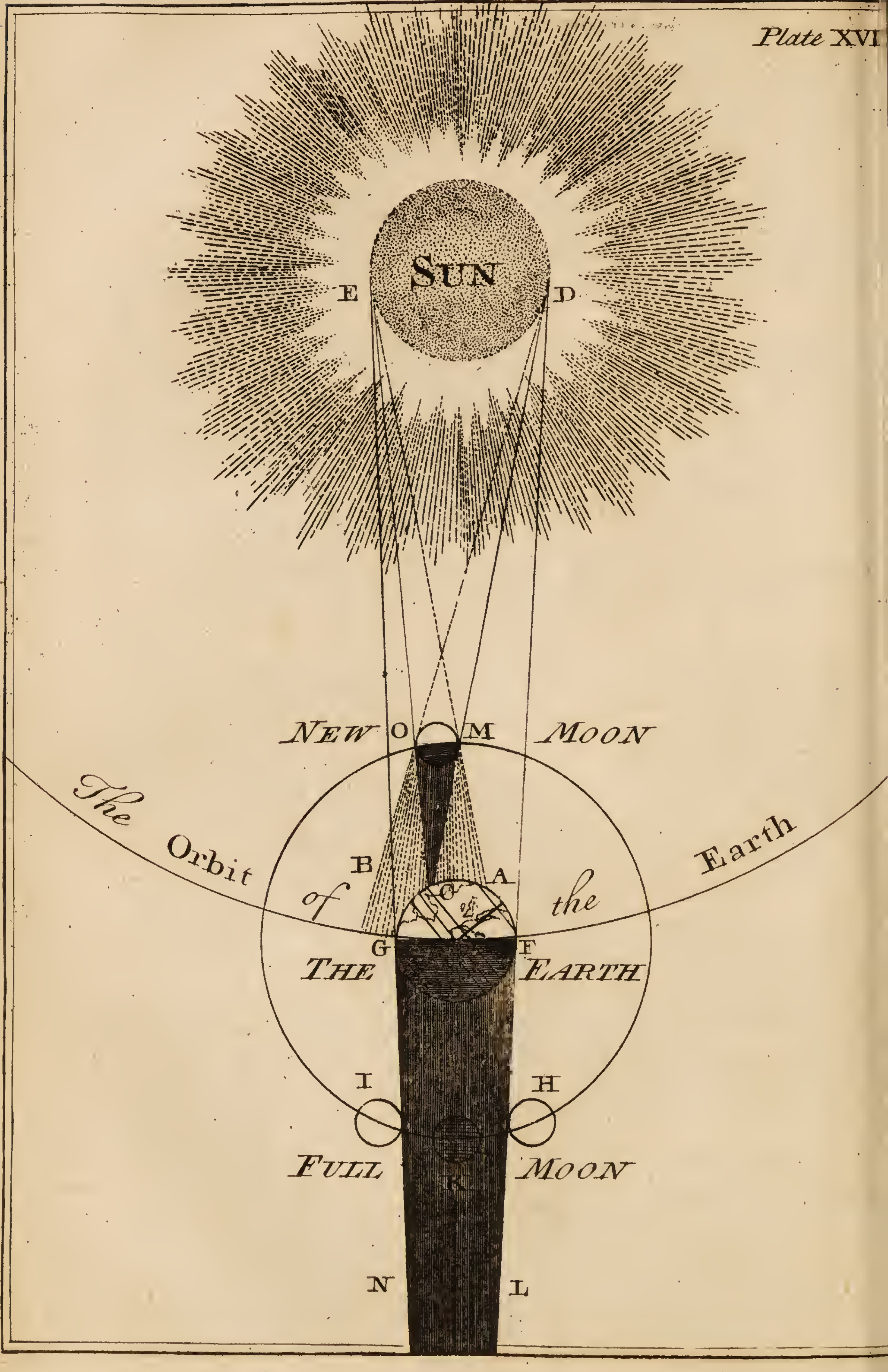
Cleon. I am glad to ſee you underſtand the Nature of an Eclipſe ſo well; you will as eaſily conceive that this penumbral Shadow will be darker about C, and leſs ſo towards the Extremities of the Cone A and B, were it becomes inſenſible.

Euphroſ. I do, *Cleonicus*; but ſee, the Time is at Hand for the Eclipſe to begin—It wants 5½ Minutes by my Watch.

Cleon.

An Eclipse of the SUN and MOON

Plate XVI



Cleon. Well, we are prepared for it, happen as ſoon as it will; I have fixed the Teleſcope in a proper Poſition for viewing it; and thereby you will ſee it in the Heavens. I have alſo darkened the Chamber, wherein you will ſee the Eclipſe in Miniature very perfectly; and have ſo ordered it that you only need to ſtep out of one Room into another to ſee both.

Euphroſ. Dear *Cleonicus* I am greatly obliged to you; but let me ſeat myſelf at the Teleſcope to obſerve the Beginning.

Cleon. Do ſo immediately; there is a Piece of black Glaſs before the Eye-Glaſs in the Teleſcope, through which you may view the Sun without hurting your Eyes.

Euphroſ. Very good, *Cleonicus*; let me view him —— I ſee his glorious Face, and the ſeveral Spots which beautify it —— there is yet no Appearance of an Eclipſe.

Cleon. In half a Minute you'll ſee it.

Euphroſ. I do: ——— The Moon juſt touches him on the right Side ——— and covers a very ſmall Part ——— let me ſee it in the Chamber —

Cleon. Look in —

Euphroſ. 'Tis juſt as I ſaw it at large in the Teleſcope, how beautiful it appears in that ſmall Picture! But here it begins on the left Side, how is that?

Cleon. That is, becauſe the Image of the Sun is inverted by the ſingle Glaſs in the Scioptric Ball — See, there is a large Spot, which the Moon will preſently hide, — view it in the Teleſcope —

Euphroſ. I will —The Moon is almoſt upon it — it diſappears — alſo another ſmall Spot below — ſhe advances apace — the Sun is near one quarter eclipſed — I'll ſee it now in the dark Chamber —

Cleon. Do; I'll look thro' the Tube — Tell when you ſee a Spot juſt going to be hid —

Euphroſ. I will — the dark Circle is very near one on the upper Part ——

Cleon. I ſee it, — ſpeak when it diſappears —

Euphroſ. The Moon juſt touches it — 'tis gone. ——

Cleon. I obſerved it the Inſtant you ſpoke; from hence you ſee how truly every thing in the Heavens is repreſented in the picturing of a dark Chamber.

Euphroſ. Very finely, indeed; I never obſerved an Eclipſe with ſo much Pleaſure and Exactneſs before — But ſee, methinks it begins to appear ſomewhat darkiſh, or elſe 'tis my Fancy ——

Cleon. The Sun is now about two thirds eclipſed, and the Day-light begins to be ſenſibly diminiſhed, and will be ſo in a few Minutes. —

Euphroſ. 'Tis darker than it was — I'll view the Sun again — he appears horned like the Moon in her laſt Quarter; — a great Cluſter of Spots will be hid by-and-by. ——

Cleon. They will ſo — the Darkneſs increaſes very ſenſibly — the Air ſeems obſcured, you will quickly ſee the Stars —

Euphroſ. The Stars! Will it be ſo dark as to make them viſible?

Cleon. Viſible, yes, for a conſiderable Time; you will ſee Day converted into Night —

Euphroſ. Bleſs me, you make me ſhudder at the Thought. — The Spots are gone, *Cleonicus.*

Cleon. They are, I ſee, in the Image—ſee, from the Window, how the People ſtare and are ſurprized in the Street ——

Euphroſ. Surpriz'd, and well they may; I believe they never ſaw it ſo dark in the Day-time before —— How dark it is!

Cleon. It will be much darker by-and-by — in about three or four Minutes the Sun will be totally eclipſed —

Euphroſ. I find it cold too, as well as dark, *Cleonicus.*

Cleon. It is cold — ſee the Owl flying over yonder Meadow — ſhe thinks 'tis Night ——

Euphroſ. I ſee her — ſhe hallows too — Hark! there's a general Murmur in the Streets — I heard one ſay he believed the World was going to be at an End —

Cleon. Very likely; they can't tell what to think of a Thing ſo very ſtrange — See, yonder, a large Star appears ——

Euphroſ. I ſee it — and many more — I believe the Sun is nearly quite eclipſed — The Birds chirrup, cry, and fly to the Hedges, as if very much frighten'd ——

Cleon. They really are ſo—the Sun is now as much eclipſed as it can be —

Euphroſ. Then I now ſee the Ring, which you ſpake of, which the Moon leaves upon the Rim of the Sun ——

Cleon. Thus you ſee the Moon appears leſs than the Sun — We are now in the *Dark Shadow*, which will not continue long — the Stars all appear —

Euphroſ. Look, ſee how the Beaſts run under the Trees — what do the poor Creatures think!

Cleon. Think! they can't tell what the Matter is, — they know 'tis ſomething very extraordinary — There has been many a Night not ſo dark as it is now.

Euphroſ. That I am ſure of — well 'tis very ſurprizing —

Cleon. So it is, to ſee the *two great Lights* of Heaven in a manner both extinguiſhed!

Euphroſ. The greateſt Darkneſs is over I ſee — Pray, was it ever ſo dark in an Eclipſe before?

Cleon. Yes, and rather darker ſometimes; for it may now and then happen that at the Time of an Eclipſe the Moon may be at ſuch a Diſtance from the Sun as to appear ſomewhat larger than the Sun, and ſo will entirely hide his whole Face; whereas now a ſmall Ringlet appears; and this is more properly called a *Central* than a *Total Eclipſe* of the Sun.

Euphroſ. Do there often happen ſuch very great and total Eclipſes of the Sun?

Cleon. To ſome Part of the Earth or other there does; but not in any one Place; for in *England* I know not of above two total Eclipſes that has happened in this or the laſt Century, *viz.* one in 1652, on *Monday*, *March* 29; and the other in 1715, 21ſt of *April*, when it was total about two Minutes of Time. The next great Eclipſe happened in 1737, Feb. 18. Another pretty large one happened in 1748 on the 13th of *July*; beſides theſe, we have no other to happen 'till the Year 1764, when more than five Parts out of ſix of the Sun's Diameter will be eclipſed.

Euphroſ. The Thing would not be ſo ſtrange if it happened often. — The Sun recovers his Splendor apace — the Stars begin to diſappear; and the Beaſts retreat from their Coverts to the open Fields again.

Cleon. Yes, 'twill ſoon be Day once more, but a ſhort one; theſe ecliptic Nights laſt but a little Time; they are ſcarce ſufficient for a Nap ———

Euphroſ. Pray, how large may the dark Shadow of the Moon be on the Part of the Earth which it ſweeps?

Cleon. When at a Mean, it takes in the Compaſs of about 150 Miles; and when greateſt it extends to 220 Miles.

Euphroſ. But what you call the Penumbral Shadow, I ſee, is vaſtly larger ———

Cleon. Yes, it is ſo; it involves a Part of the Earth's Surface, no leſs than about *four thouſand three hundred and ninety-ſeven Miles* over, at a Mean; and when greateſt, it takes in about 600 Miles more; and therefore all People about us, to the Diſtance of near two thouſand and five hundred Miles, will ſee the Sun eclipſed more or leſs.

Euphroſ. The Eclipſe, I ſee, is nearly at an End; I do aſſure you, *Cleonicus*, I never ſpent $2\frac{1}{4}$ Hours with more Pleaſure, and agreeable Surprize than now. —If you pleaſe, we will now go drink Tea, and then I ſhall trouble you with a few more Queſtions about an Eclipſe of the Moon.

Cleon. With all my Heart, my *Euphroſyne*; you know nothing gives me a greater Pleaſure than to ſatisfy your Enquiries about natural Things.

DIALOGUE VI.

Of an ECLIPSE *of the* MOON.

Euphroſyne.

AS the Eclipſes of the Sun which are viſible to us muſt always happen in the Day-time, ſo thoſe of the Moon muſt ever be in the Night, I conceive, *Cleonicus*.

Cleon. And very juſtly, Siſter; for ſince an Eclipſe of the Moon can never happen, but when the Moon is at full; and ſince the Moon is then in Oppoſition to the Sun, ſhe will riſe when the Sun ſets; therefore no Eclipſe of the Moon can be ſeen by us till after Sun-ſet. But the Moon may, and often does, riſe and ſet eclipſed as well as the Sun.

Euphroſ. As I ſaid before, I need not aſk how an Eclipſe of the Moon happens, for 'tis plain from the Scheme, that it is by the Moon's paſſing thro' the dark Shadow of the Earth FGLN.

Cleon. It is ſo; for the Earth at that Time coming between the Sun and Moon, and being much larger than the Moon, does caſt ſo large a Shadow as often involves the Moon a conſiderable Time therein. According to *Lucretius:*

So whilſt the Moons their monthly Courſes run
Within the Reach of Earth's dark ſhadowing Cone,
The Earth, revengeful, ſtops the ſtreaming Light,
And hides the ſick'ning Moon in Gloom of Night.

Euphroſ. The *ſick'ning Moon.* I think it is a very beautiful Metaphor on that Occaſion.

Cleon. It is ſo; and it is only a Metaphor in the Poet; but the Vulgar among the Ancients did indeed believe that the Moon was actually *ſick*, and laboured as in an Agony, and ſuffered a Kind of *Death.*

Euphroſ. Indeed! Pray, how came they by ſuch a Notion?

Cleon. Their Superſtition taught them to look on the Moon as the Goddeſs who preſided over the Earth; and their Credulity (for the Ignorant believe any thing) made them fit Fools for Magicians and Inchanters to work upon; for theſe deceitful Wretches made them believe that it was in their Power to bring the Goddeſs down from her Sphere, and to torture her by muttering over ſome Charms and Incantations in Verſe; to which *Milton* thus ironically alludes,

Not uglier followed the Night Hag, when call'd
In ſecret riding thro' the Air, ſhe comes
Lured by the Smell of infant Blood to dance
With Lapland *Witches, while the lab'ring Moon*
Eclipſes at their Charms. ———

And alſo *Butler*;

Or putting Tricks upon the Moon,
Which by Confederacy are done.
Your antient Conjurers were wont
To make her from her Sphere diſmount;
And to their Incantations ſtoop ———

Yea, ſo great was the Stupidity and Ignorance of the Ancients that even *Steſichorus* and *Pindar*, two Poets of great Name, were of this ridiculous Opinion, if we believe *Pliny* the Hiſtorian.

Euphroſ. And, pray, what did the poor deluded Mortals do in Behalf of their Deity, in ſuch a diſaſtrous Caſe.

Cleon. Do! You'll ſmile to hear they endeavoured to relieve her by ringing of Bells, ſounding Trumpets, beating of braſs Veſſels, and making great Noiſes by hallowing, hooting, *&c.* to drown the muttering of Witches that the Moon might not hear them, and ſo receive no Harm. According to *Lee*'s Imitation in his *Oedipus* ———

— The ſilver Moon is all o'er Blood:
A ſetting Crimſon ſtains her beauteous Face;
Sound there, ſound all our Inſtruments of War,
Clarions, and Trumpets, ſilver, braſs, and iron,
And beat a thouſand Drums to help her Labour.

And *Medea*, boaſting of her inchanting Power in *Ovid*, ſays,

I cleave the Rocks, the knotted Oaks I break,
Remove the Foreſts, and the Mountains ſhake;
Force Earth to groan thro' all her hollow Caves,
And call the ſlumb'ring Ghoſts from ſilent Graves.
Thee too, O Luna! *from thy Sphere I call,*
Tho' Braſs relieves thee, and obſtructs thy Fall.
METAM. *Lib.* VII.

And thus *Tibullus*;

Whene'er the Moon is forc'd from wand'ring Stars,
The Midwife Nations ſound from far the Braſs.

And laſtly, *Juvenal*, ſpeaking of a loud ſcolding Woman, ſays pleaſantly, that ſhe alone was able to relieve the Moon out of the Labour of an Eclipſe ———

Forbear your Drums and Trumpets, if you pleaſe,
Her Voice alone the lab'ring Moon can eaſe.

And this ſtrange and abſurd Piece of Superſtition is practiſed to this Day among the *Turks* and *Heathen* Nations with many and various ridiculous Ceremonies more than I have related, as Hiſtorians inform us.

Euphroſ. Well, you have entertained me with a pleaſant Digreſſion, which thoroughly convinces me how neceſſary it is for every one to ſtudy Philoſophy who would have but a tolerable Notion of Things, and not be abſurd and ridiculous in his Sentiments. But to return to the Matter — Pray, in how many Particulars does an *Eclipſe of the Moon* differ from an *Eclipſe of the Sun?*

Cleon. In the following, *viz.* Firſt, The Moon is really and truly eclipſed by the Shadow of the Earth; whereas in a *Solar Eclipſe* the Sun is not eclipſed, but the Earth by the Shadow of the Moon.

Secondly; An Eclipſe of the Moon begins on the Eaſt Side or Limb, and ends on the Weſt; but the contrary happens in a Solar Eclipſe.

Thirdly; The Lunar Eclipſes are more frequent to any one Place than Solar Eclipſes. Becauſe,

Fourthly; An Eclipſe of the Moon appears from all Parts of the Earth to be the ſame as it really is; whereas an Eclipſe of the Sun does not; but may be total in one Part, partial in another, and none at all to others, at the ſame Time.

Fifthly; But Solar Eclipſes are more frequent with reſpect to the whole Earth than the Lunar ones; becauſe the large Penumbra of the Moon can oftener fall on the broad Surface of the Earth than the ſmall Globe of the Moon can fall into the conical Shadow of the Earth.

Sixthly; The total Darkneſs of a Lunar Eclipſe laſteth $1\frac{1}{2}$ Hour, ſometimes more; but that of a Solar Eclipſe not above two Minutes.

Theſe are the principal Differences of Eclipſes, Solar and Lunar.

Euphroſ. I thank you, *Cleonicus*; you take a great deal of Pains with me; but one Queſtion more. Pray, do you know the Dimenſions of the Earth's Shadow at the Diſtance of the Moon?

Cleon. Yes; the Shadow of the Earth, where the Moon paſſes through it, is about 5900 Miles in Diameter, which is almoſt three Times the Diameter of the Moon.

Euphroſ. How long may an Eclipſe of the Moon continue from firſt to laſt when greateſt?

Cleon. From the Time of the Moon's Immerſion into the Shadow at I, to the Time of her Emerſion at H, is ſometimes $3\frac{1}{2}$ Hours, and ſometimes more; and the Time of total Darkneſs is generally $1\frac{1}{2}$ Hour, as I told you before.

Euphroſ. I have a few more Queſtions concerning Eclipſes that I want reſolved; but on Account of the Viſit we are to make this Evening muſt refer them to another Seaſon.

DIALOGUE VII.

Of the Boundaries, and Number of Eclipſes, and the Times of the Year when they happen.

Cleonicus.

I Remember, *Euphroſyne*, you told me, when we laſt diſcourſed of Eclipſes, you had ſeveral Queſtions more to aſk concerning them; if you'll now propoſe them I'll endeavour to give you Satisfaction in each Particular.

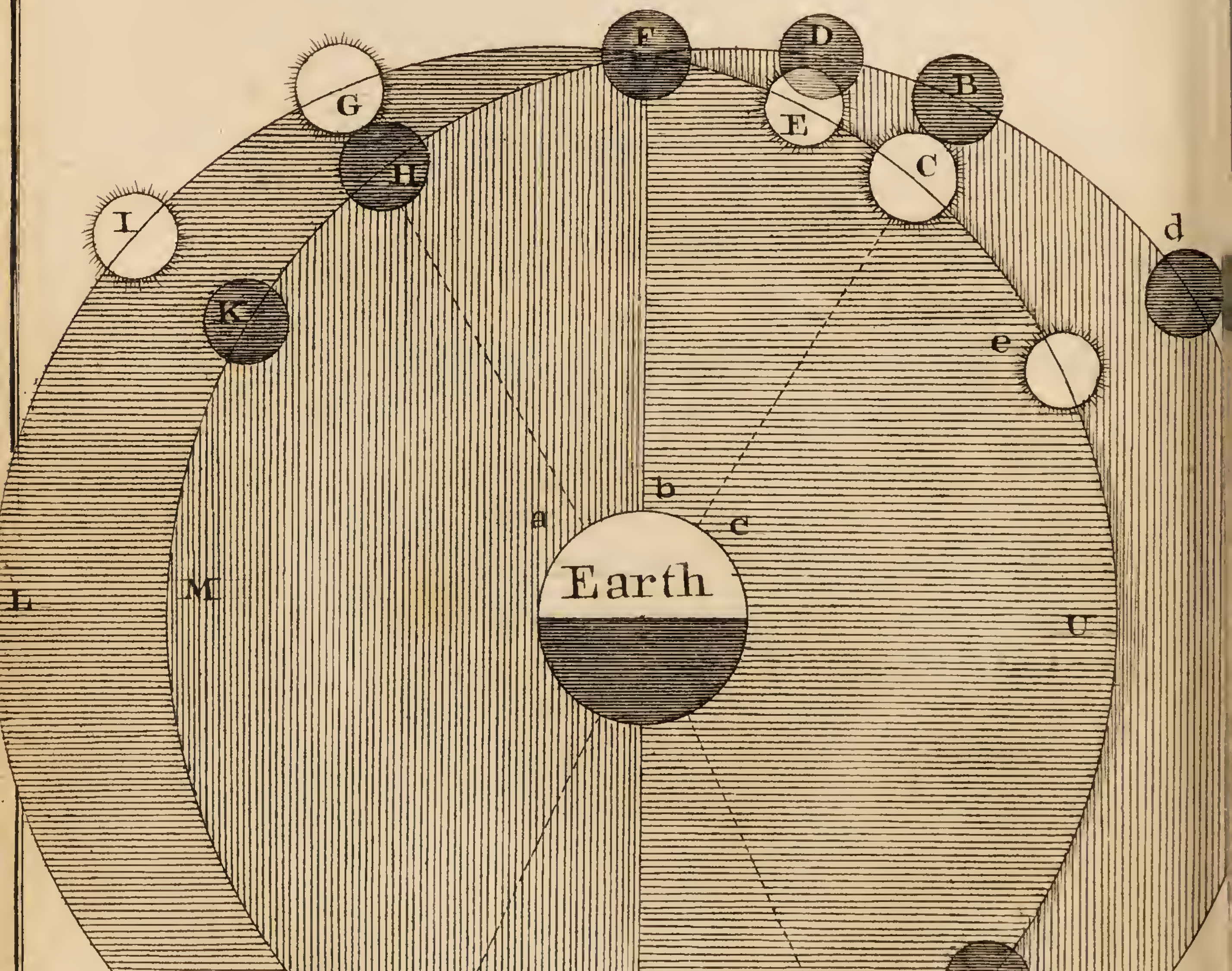
Euphroſ. One thing I have often wanted to know, why our Almanacks of ſeveral Years preſent us with different Numbers of Eclipſes, ſometimes they tell us we ſhall have *two*, ſometimes *four*, and at other Times *ſix*: Alſo, why they happen at ſome certain *new* and *full Moons* and not at others; and other ſuch like Matters.

Cleon. That I may give you a good Idea of ſuch Things, it is neceſſary you ſhould conceive it by a little eaſy Inſtrument of two circular Pieces of Paſteboard which I have here prepared, and contrived to ſhew the Nature of the Thing. One of theſe Pieces AFMP is to repreſent the Plane of the Moon's Orbit. —

Euphroſ. Very good! and what is the other deſign'd for?

The Limits of SOLAR and LUNAR Eclipses

Plate XVII.



Cleon. The other Piece UFLP, repreſents the Plane in which the Sun, or the Earth's Shadow appears to move in at the Diſtance of the Moon. For in the Firmament, the Sun ſeems to go in the ſame Tract very nearly with the Moon; and if the conical Shadow of the Earth were cut through, at the Diſtance of the Moon, that Section would appear a dark circular Space, and to move in the ſame Tract with the Sun.

Euphroſ. Well; and how then?

Cleon. Then the Edge of the circular Piece AFMP will repreſent the Orbit of the Moon, and that of the other Piece the Orbit of the Sun, or (in other Words) the Ecliptic, at the Diſtance of the Moon.

Euphroſ. So far I apprehend you pretty well; pray, proceed.

Cleon. In the laſt Place, you muſt know, that the Plane of the Moon's Orbit does not lie exactly level with the Plane of the Ecliptic, but one Half below it, and the other above it, juſt as you ſee me put theſe two Pictures of Paſtboard together.

Euphroſ. I ſee your Meaning plain; the Half FAP lies below the Ecliptic, and the other Half FMP above it.

Cleon. Well, then the Diſtance between theſe Planes at their Extremities is called the *Latitude of the Moon*; that below the Ecliptic is the *South Latitude*, the other above it the *North Latitude*; becauſe the Moon in deſcribing the lower Part EAP is Southward of the Sun; but in the other Half FMP ſhe is Northward of it.

Euphroſ. I underſtand you ſo far very well; pray go on.

Cleon. Alſo the Points F and P, where the Planes croſs each other, are called the *Nodes*; and F the *Aſcending Node*, becauſe there the Moon riſes above the Ecliptic, and is thus marked ☊; the other, P, is the *Deſcending Node*, marked thus ☋: And now having ſufficiently explained the Inſtrument, it will be very eaſy to underſtand the Things you enquire farther of Eclipſes.

Euphroſ. If ſo, I ſhall be very glad; and pray let me know when, or in what Part of the Moon's Orbit there may, and when there may not be an Eclipſe?

Cleon. I ſhall ſatisfy your Enquiry firſt of *Solar Eclipſes*; and therefore from what I have already ſaid, you will eaſily conceive, that a Spectator at the Earth, *a b c*, will view the apparent Faces of the Sun and Moon very nearly equal at the Diſtance of the Moon; and conſequently the Moon journeying round every Month in her Orbit AFMP, and the equal Solar Diſk moving round the Ecliptic UFLP, which two Orbits interſect each other at F and P; it muſt happen that in the Courſe of a Year the Sun will be ſeen in the Nodes F and P, at two different, and almoſt oppoſite Seaſons of the Year; and will be for ſome Time ſo near them on each Side, that when the new Moon paſſes that Part of her Orbit, ſhe muſt neceſſarily hide or cover either the Whole or Part of the Sun's Diſk or Face, and ſo produce an *Eclipſe of the Sun*, total or partial: For ſince the Inclination or Diſtance between the two Orbits grows leſs and leſs from AU, where it is greateſt, towards the Nodes where it is nothing; ſo there muſt be a certain viſible Latitude or Diſtance as at C, B, which is juſt equal to the Sum of half the Diameters of the Moon B, and Sun C; (becauſe the greateſt Latitude, AU or IM, far exceeds that Sum.) Again, ſince the viſible Latitude BC is equal to the half Diameters of the Sun and Moon, the Moon in paſſing along will juſt touch the lower or Southern Limb of the Sun, but cover no Part of his Surface: Conſequently any new Moon before the Point B, as at *d*, will have ſuch a Latitude from the Sun at *e*, as will exceed the Sum of their half Diameters, and ſo will be ſeen to paſs at ſome Diſtance below the Sun, and not touch it.—But if the new Moon appears nearer to the Node F, as at D, where her Latitude from the Sun at E is leſs than the ſaid Sum of the half Diameters of the Sun and Moon, then the Moon will be ſeen to paſs over a Part of the Sun's Diſk, and ſo cauſe a *partial Eclipſe* of the Sun where it is viſible.

Once more; if the new Moon happens in the very Node itſelf, as at P, the Sun being there alſo, the Moon then having no Latitude muſt neceſſarily paſs over the whole Diſk of the Sun, and ſo produce a *central* and *total Eclipſe of the Sun.*

Laſtly; New Moons on the other Side of the Node F, to the ſame Diſtance G H, will produce Eclipſes, more or leſs, on the upper or northern Part of the Sun; but at H the Sum of the half Diameters and viſible Latitude being again equal, the Luminaries will there but juſt touch each other; and in all Parts farther from the Node, as at K, there will be no Eclipſe poſſible; for the Moon will then paſs above the Diſk of the Sun.

Euphroſ. It is all very evident; and therefore I preſume the Points B and H in the Moon's Orbit are what you call the *ecliptic Boundaries*, or *Limits of Solar Eclipſes.*

Cleon. Yes, they are ſo; and now with Reſpect to *Lunar Eclipſes*, we muſt turn our Eye to the oppoſite Parts of the Orbits on each Side the Node P, where we ſhall view the *Full-Moon* in her Orbit, and the Section of the Earth's Shadow at the Diſtance of the Moon's Orbit in the Points O, P, Q, S.

Now, in the firſt Place, let us conſider that if the *Full-Moon* happens at N or R, where the Earth's Shadow paſſing by juſt touches it, then in any Point between N and R, the ſaid Shadow will more or leſs involve the Moon, and ſo cauſe a *Lunar Eclipſe* in a greater or leſſer Degree; and therefore thoſe two Points, N and R, in the Lunar Orbit, where the Sum of the half Diameters of the Moon and Earth's Shadow is equal to the true Latitude of the Moon, are the *Boundaries* or *Limits of Lunar Eclipſes*, on each Side the Node P.

Again, in the ſecond Place; the nearer the Moon is to the Node P, the greater will be the Eclipſe, and therefore greateſt of all, and central, in the Node itſelf, where the Shadow of the Earth is near three Times greater than the Moon, as I formerly told you.

Euphroſ. The Manner of explaining the Boundaries of a *Lunar Eclipſe* I ſee is the ſame nearly as that of the Solar ones, and as eaſily underſtood. But unleſs I could tell which were greateſt, the *Sum of the half Diameters of the Sun and Moon*, or of the *Shadow and Moon*, I can't tell which would be greateſt, the Limits of a *Solar or Lunar Eclipſe.*

Cleon. Though the latter Sum be in itſelf greater than the former, yet the former, with Reſpect to the *viſible Latitude* of the Moon, is greater than the latter, in Regard of her true *Latitude*; and therefore the *Limits of a Solar Eclipſe exceed thoſe of a Lunar one.*

Euphroſ. I ſhould be glad to know in what Time the Sun moves over the ecliptic Limit CG.

Cleon. Theſe Limits are ſomewhat variable; but when C G is leaſt, the Sun takes up about 28 Days in paſſing over it, and 32 Days when greateſt.

Euphroſ. And pray what is the Time between one new Moon and another?

Cleon. Twenty-nine Days and an half.

Euphroſ. Why then, when the Limit CG is greateſt, there muſt neceſſarily be an Eclipſe of the Sun during his Stay within that Limit; but when it is leaſt, I perceive it is poſſible there may be no Eclipſe of the Sun that Node.

Cleon. 'Tis indeed poſſible there may not; but the Chance there will not is ſo very great, that it was never known to happen, I believe. On the other Hand, when the Limit is leaſt there is *one* Eclipſe very certain, and there may be *two* when greateſt; and this ſometimes happens, as in the Year 1736, 1743, *&c.* But theſe twin Eclipſes are very ſmall, and almoſt always to us inviſible.

Euphroſ. Of all this I conceive the Reaſon pretty well; and now for the other Node: Pray how long is the Shadow of the Earth within the *Lunar Limit* OQ?

Cleon. This Limit is alſo variable; and when greateſt, the Shadow paſſeth it in 24 Days; and when leaſt, in 19 Days.

Euphroſ. Then ſince from Full Moon to Full Moon there is 29 Days and an half, if the Full Moon ſhould happen in the Beginning of the Limit, as at N, before the Moon could again return to the ſame Node, the Shadow would be paſt the other Limit Q; and ſo there would be no Eclipſe of the Moon, in ſuch a Caſe, that Node, even when the Limit is the greateſt of all.

Cleon. Very well obſerved, *Euphroſyne*; nor can there ever be two Lunar Eclipſes together at the ſame Node, when the Limit is greateſt; ſo that upon the whole you ſee there can be but one Eclipſe of the Moon within the Lunar Limits, and ſometimes none at all.

Euphroſ. Then I ſee 'tis poſſible, that in ſome Years there may be no Lunar Eclipſe at all.

Cleon. Yes, it is; and thus it happened in the Years 1734, 1738, 1745, 1752, the preſent Year 1756, and 1763; for in theſe Years there was no Eclipſe of the Moon; and but two of the Sun, and both inviſible to us, except that of *Auguſt* the 3d, 1738.

Euphroſ. We find by Experience that the Solar and Lunar Eclipſes happen both at the ſame Times of the Year, which is alſo evident from the Inſtrument.

Cleon. It is ſo; for the new Moon, which obſcures the Sun in the Solar Limit, is itſelf eclipſed by the Shadow of the Earth at the Lunar Limit, when it is next at Full.

Euphroſ. I underſtand you very well; and I farther obſerve, that as the Nodes F and P are in oppoſite Points of the Orbit, ſo after half a Year, the Nodes will change their Nature, and that which is now the *Solar Node* will then become the *Lunar*; and the *Lunar Node* that now is, will then become the *Solar Node*, and will be the Seaſon of Eclipſes again.

Cleon. It will not be quite half a Year between, becauſe the Sun, for Inſtance, may be eclipſed at the End of one Limit, as at G, (as in the Year 1732, *Dec.* 6.) and at the Beginning of the other at O, (as *May* 2, 1733) in which Time there intervened not above 147 Days, which is ſhort of half a Year by 35 Days. Yea, the Sun may leave one Limit, and arrive to the next in about four Months and an half, as in the Year 1740 the Sun was eclipſed *Jan.* 17, and again in *June* 12; and another Reaſon for this is, that the Nodes F and P are not fixed, but move in a retrogade Manner, ſo as that the diſtant Node is carried towards the Sun, and they meet near ten Days ſooner than if the Node were fixed.

Euphroſ. Well, I am not now ſo much at a Loſs to gueſs the Reaſon why we have in different Years a different Number of Eclipſes; why one Year *four*, another Year *two*, and a third Year *five* or *ſix*; and alſo the Reaſon why they happen at ſuch and ſuch Intervals and Seaſons of the Year: This Doctrine of Nodes and Limits has given me the *Rationale* of Eclipſes beyond whatever I expected; and now to be plain with you, I am got to a *ne plus ultra*, for I know not what further to aſk or ſay on the Subject of Eclipſes.

Cleon. We have pretty well exhauſted the Subject, indeed, *Euphroſyne*, and I ſhall only obſerve to you next, that the Year 1740 had ſix Eclipſes in a very peculiar Manner; for in thoſe Years wherein ſix Eclipſes happen, there are generally *two of the Sun and one of the Moon* at each ecliptic Seaſon; but in that Year there were three ecliptic Seaſons, or the Luminaries came three Times within the ecliptic Limits, and each of them ſuffered an Eclipſe each Time; ſo that in that Year there were three Eclipſes of the Sun, and three of the Moon; a Thing which very rarely happens. But Eclipſes, like all other Things, in a long Courſe of Time, undergo a great Variety of Mutations and Changes, in the Circumſtances we have now been conſidering.

> *Thus I've the Motions taught of* STARS *above,*
> *Of* SUN, *and* MOON, *and by what Cauſe they move;*
> *And how* eclipſed *they looſe their gaudy Light,*
> *And ſpread o'er all an unexpected Night,*
> *As if they wink'd, and then with open Eyes*
> *View'd all again, and clear'd the lower Skies.*
>
> Creech's Lucretius, Book V.

DIALOGUE VIII.

Reflections on the Immenſity of the Univerſe, and of the Plurality of Worlds.

Euphroſyne.

THE Converſations which have paſſed between us of late have opened a new and ſtrange Scene of Things to my Mind, and given quite a new Turn to my Thought; I uſed to fancy the Earth on which we live, and the viſible Lights of Heaven were all the Creation, the Whole of the Univerſe; nor did I ever imagine God had more than once ſaid, *Let us make Man.* I thought we had held the ſecond Claſs of created Beings, and muſt acknowledge Superiority only to Angels. But what can we think of ourſelves, *Cleonicus*, if every Planet be a World, and every Star the central Sun of a Syſtem? If every Syſtem be inhabited, and thoſe Inhabitants various as the Globes they live on!

Cleonicus. We can't certainly tell what to think, my *Euphroſyne*; the *Idea* is too grand for human Comprehenſion; even Reaſon, Nature, and Analogy here are but blind Guides; they conduct us with Certainty but a little Way in the Abſtruſities of infinite Creation; and e'er we have paſſed, as it were, the Threſhold of the Univerſe, we are loſt and confounded. With the Poet we may ſay —

Now had th' eternal Architect ſupreme,
In Ampliture ſtretch'd out this wond'rous Frame;
Equipt magnificent, the Houſe of God,
Through Heighth and Depth, his boundleſs, bleſt Abode;
One Houſe, one World, one Univerſe divine,
Where countleſs Orbs thro' countleſs Syſtems ſhine.
Syſtems! which view'd throughout the Circuit wide,
Or loſt — or ſcarce the pointed Sight abide.
(Thro' Space immenſe, with Diminution ſeen)
Yet boundleſs, to thoſe Worlds that roll within;
Each World as boundleſs, to its native Race,
That range, and wanton thro' its ample Space;
Frequent thro' Fields, thro' Clouds of Fragrance ſtray.
Or ſkim the wat'ry, or ethereal Way.

Univerſal Beauty.

Euphroſ. The Poet's Reflections are certainly juſt; they do indeed inſpire us with noble and auguſt Sentiments of the divine Being: He has made, and by his Providence governs, not *one*, but *an Infinity of Worlds!* How narrow muſt their Conceptions be, who imagine our Earth contains the whole of the rational Species, or that Heaven is to be repleniſhed with Colonies from this little Spot alone!

Cleon. Very true, Siſter; our Earth's a little Spot indeed, and inconſiderable in Compariſon of the more noble Parts of this, much more of thoſe of innumerable other Syſtems. In Regard of which, Mr. *Baker* thus expoſtulates with opinionated Man.

What is this Earth, *of which thou art ſo proud?*
Loſt and unknown in the more glorious Crowd,

A Point it ſcarce appears.—E'er it begun,
The Reſt their Courſes have——
And ſhall, when it's no more, to endleſs Ages run.
Univerſe.

Euphroſ. Our Earth to be ſure can be conſiderable to no Part of the Univerſe but ourſelves, and perhaps to the Inhabitants of the Moon, who behold it as a very large and bright Moon; but as to all other Worlds, *Mercury*, *Venus*, and *Mars* excepted, the Exiſtence of our Earth, (I find by what you have ſaid) is neither known or ſuſpected by them: And if the Earth be not, then ſurely its Inhabitants muſt be abſolutely unknown, and inconſiderable with Reſpect to the Univerſe.

Cleon. Your Obſervation is very juſt, *Euphroſyne*; and yet you ſee what an high Value Mankind are apt to put upon themſelves. Becauſe we are ſuperior to *Brutes*, we imagine we are next to *Angels* in the Scale of Beings: Becauſe we have Dominion over the Fowls of the Heavens, and Beaſts of the Earth, we invade the Stars, and claim a Sovereignty over all the celeſtial Worlds, becauſe this terreſtrial Spot is put under his Feet. But how abſurb, how ridiculous is our Vanity, in thinking all Things made for our Uſe, when the utmoſt Uſe we make of any Thing about us is but very trifling: Of all the numberleſs Species of Animals, how few do we know? how few do we uſe? how many do we fear? how many do we fly from? Again, do we boaſt the Uſe of the Sun? ſo may the moſt contemptible Inſect: Does the Moon light up the Night for us? ſo it does for the Owls, &c. alſo. If all the Planets of our Syſtem were annihilated, few beſides Aſtronomers would miſs them. Laſtly, who is the Man that can ſay any one ſingle Circumſtance of his Life was ever affected or altered by any one, yea, all of the fixed Stars? The Pride, therefore, and Arrogance of Man in challenging to himſelf the Empire of the Univerſe, are handſomely laſhed by the Satire and Irony of the following Verſes.

Where's now thy Pride, which lately dar'd to ſay,
The Stars *were only made to light thy Way,*
And all the Univerſe *thy Pleaſure to obey?*

What impious Madneſs urg'd thee on to call
Thyſelf the ſole and ſovereign LORD *of all?*
If ſuch thou art, let ſome plain Proof be ſhown,
And make thine Empire o'er thy Vaſſals known.
Bid the Sun ſhine; command the Winds to ceaſe:
Make the Rains fall; or chide the Seas to Peace.
What! are theſe deaf?—Once more exert thy Sway:
Try which of all thy Subjects will obey:
Enjoin the Tyger to refrain from Blood,
Or bid the Crocodile provide thy Food.
Theſe know their King, perhaps, and will comply.---
Hail, mighty Lord!- -What! does the Monarch fly?
Unhappy Prince! whoſe impotent Command
The meaneſt of thy Veſſals dares withſtand,
And wreſt the Sceptre from thy feeble Hand.

Univerſe.

Euphroſ. Your rehearſing thoſe Lines brings to my Mind a Fable of the late ingenious Mr. *Gay*, of the *Man* and *Flea*, to this Purpoſe——

What Dignity's in Human Nature,
Says Man, the moſt conceited Creature,
As from a Cliff he caſt his Eye,
And view'd the Sea and arched Sky!
The Sun was ſunk beneath the Main,
The Moon, and all the ſtarry Train,
Hung the vaſt Vault of Heav'n. The Man
His Contemplation thus began.
When I behold this glorious Show,
And the wide wat'ry World below,
The ſcaly People of the Main,
The Beaſts that range the Wood or Plain,
The wing'd Inhabitants of the Air,
The Day, the Night, the various Year,
And know all theſe by Heav'n deſign'd
As Gifts to pleaſure Human Kind.
I cannot raiſe my Worth too high;
Of what vaſt Conſequence am I!

Not of th' Importance you ſuppoſe,
Replies a FLEA *upon his Noſe:*
Be humble, learn thyſelf to ſcan;
Know, Pride was never made for Man.
'Tis Vanity that ſwells thy Mind.
What! Heav'n and Earth for thee deſign'd!
For thee!—made only for our Need;
That more important Fleas might feed.

Cleon. The great Mr. *Pope* too makes a perfect Jeſt of the giddy, humourous Creature, Man.—

Created, half to riſe, and half to fall;
Great Lord of all Things, yet a Prey to all.
Sole Judge of Truth, in endleſs Error hurl'd;
The Glory, Jeſt, and Riddle of the World.

Yea, he makes the Angels admire the greateſt Man no otherwiſe than we do a Monkey, in theſe Lines:

Superior Beings, when of late they ſaw
A mortal Man unfold all Nature's Law,
Admir'd ſuch Wiſdom in an earthly Shape,
And ſhow'd a Newton, *as we ſhow an Ape.*

Eſſay on Man.

Euphroſ. But, pray *Cleonicus*, do not the Poets carry the Jeſt too far in thus ridiculing Mankind? Ought we not to have an higher Eſteem for Man, whom the Scripture makes the conſtant Subject of God's particular and diſtinguiſhing Providence, Care, and Goodneſs.

Cleon. Doubt not, my *Euphroſyne*, but Mankind is the ſpecial Care of God and Heaven; nor do any of the Poets or Philoſophers diſpute, or queſtion that: 'Tis the Pride, Preſumption, and Self-Conceit, not the Dignity of Man, which they lampoon. 'Tis one Thing to ſuppoſe Man the Care of God, and another to ſuppoſe him *only ſo:* We know there are Globes in our Syſtem vaſtly ſuperior to ours, and there may be in other

Syſtems, others vaſtly ſuperior to theſe; if, therefore, the Inhabitants of theſe are equally ſuperior to each other, as is reaſonable to ſuppoſe, then there are other Species of rational Beings as much ſuperior to us, perhaps, as Angels are to them, or we to Apes or Monkeys. The Scale of rational Beings does in all Probability admit of various Gradations, among which thoſe of Brute Nature are the loweſt.

Euphroſ. Indeed, I can't ſay but it ſeems a little abſurd to ſuppoſe infinite Wiſdom ſhould exhibit ſuch a wondrous Variety of Natures, Kinds, Forms, Sizes, Perfections, *&c.* in the inferior and more unworthy Part of the Creation, and be content with giving one Specimen only of a better Sort.

Cleon. And that too in one Point only, *viz.* the Power of the contemplative and reaſoning Faculties. For 'tis well known, that, with reſpect to any Senſe of the Body, Man is exceeded by ſome one or other of the irrational Tribes. The Mind is doubtleſs a noble Principle, but ſhould it be thought ſtrange to ſuppoſe that it is capable of various and different Degrees of Perfection? Or that there ſhould be Beings, who poſſeſs all theſe ſuperior Degrees, and are therefore of a more exalted Nature than ours?

Euphroſ. Well, granting what Variety of reaſonable Beings you pleaſe, I preſume you allow they are all deſigned for Heaven and Happineſs in another World: But, pray *Cleonicus*, what becomes of irrational Creatures when they die?

Cleon. By Nature only, we know but little of our own future State, and of Courſe but little or nothing of theirs. 'Tis ſottiſh to imagine that they were made to anſwer no End, but Man's Luxury, Diverſion, or Uſe. No doubt, but in the Creator there was one uniform Deſign of Happineſs and Good intended for the Whole, and to be enjoyed by every Creature, in Proportion to the Perfection of its Nature. But of what Sort or Kind this general Felicity is, and where and when to be enjoyed, is Part of the Knowledge concealed from us. That there are Strokes of ſurpriſing Wiſdom and Deſign in the meaneſt Animal we well know, and ſhall ſee more of in our future Converſations; and alſo, that there is a mutual Relation, Dependance, Harmony, and Connection in all the animated Orders of Beings; which plainly prove, that each Order, and every Individual, is of ſome Importance and Concernment to the Whole, as well as Man. According to the Poet's fine Simile.

> *Like ſome grand Building is the* UNIVERSE,
> *Where every Part is uſeful in its Place;*
> *As well the* Pins *which all together hold,*
> *As the* rich Carvings, *or the* glowing Gold.

Univerſe.

The Young GENTLEMAN and LADY's PHILOSOPHY.

PART III.

DIALOGUE I.

The Doctrine of the SPHERE; *or, a general Deſcription of the Circles thereof.*

**Cleonicus.*

WELL, my *Euphroſyne*, I make no Queſtion but the Converſations we had when I was with you laſt, have made a notable Impreſſion on your Mind, and ſupplied you with Matter of ample Meditation and Amuſement.

Euphroſyne. Greatly ſo, in each Reſpect, dear *Cleonicus*; and ſo agreeable were thoſe Studies, and ſo advantageous to my Mind and Underſtanding, that I ſhall ever reflect with Pleaſure and Gratitude on the Care and Pains you then took to inſtruct me in thoſe more than *human* (I may truly ſay *divine*) *Speculations.* You are a Stranger to the longing Expectation I have had for your Return, that I might have the Happineſs of making a farther Progreſs and Proficiency therein.

Cleon. You ſpeak in moſt engaging Accents; we will now apply every Opportunity to that Purpoſe; and as we then contemplated the Heavens in a natural and practical Way; ſo now we will farther conſider the Advantages Art has ſupplied us with to make thoſe Things ſtill more eaſy and practically uſeful. To which End we have three excellent Inſtruments contrived, *viz.* the ARMILLARY SPHERE, the ORRERY, and the GLOBES.

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* Now returned again from the Univerſity, where he is ſuppoſed to have been to purſue his Studies ſince the laſt Dialogue was finiſhed.

Euphroſ. I ſhould much delight to be acquainted with the Nature and Uſes of theſe Inſtruments, *Cleonicus.*

Cleon. That you will attain with great Eaſe; for there is nothing in them which a Genius much inferior to yours is not capable of apprehending.

Euphroſ. No Compliments, I beg of you, *Cleonicus*; I ſhall put you to prove your Words; for, if I can once underſtand theſe Machines, I ſhall have a great Opinion of myſelf as an Aſtronomer.

Cleon. And juſtly you may; nor will you then be the firſt Woman who has underſtood Aſtronomy well. Aſtronomy is a noble Science, worthy the Fair-Sex, and highly deſerving the Encomium of the Poet.

Aſtronomy! hail, Science heavenly born!
Thy Schemes the Life aſſiſt, the Mind adorn.
Thy Aids the Heaven's ſeal'd Volumes wide impart;
And taught the Seaman firſt his uſeful Art;
Gave changing Seaſons their determin'd Space,
And fix'd to Hours and Years their meaſur'd Race.

Euphroſ. So uſeful a Science urges me with Impatience to the Study of it; and, pray, which of the afore-named Inſtruments do we firſt begin with, to employ the remaining Hours of the Day?

Cleon. The ARMILLARY SPHERE, by the Knowledge of which you will naturally be led to the underſtanding of the Orrery and the Globes, on which you may practiſe all the uſeful Problems of Aſtronomy.

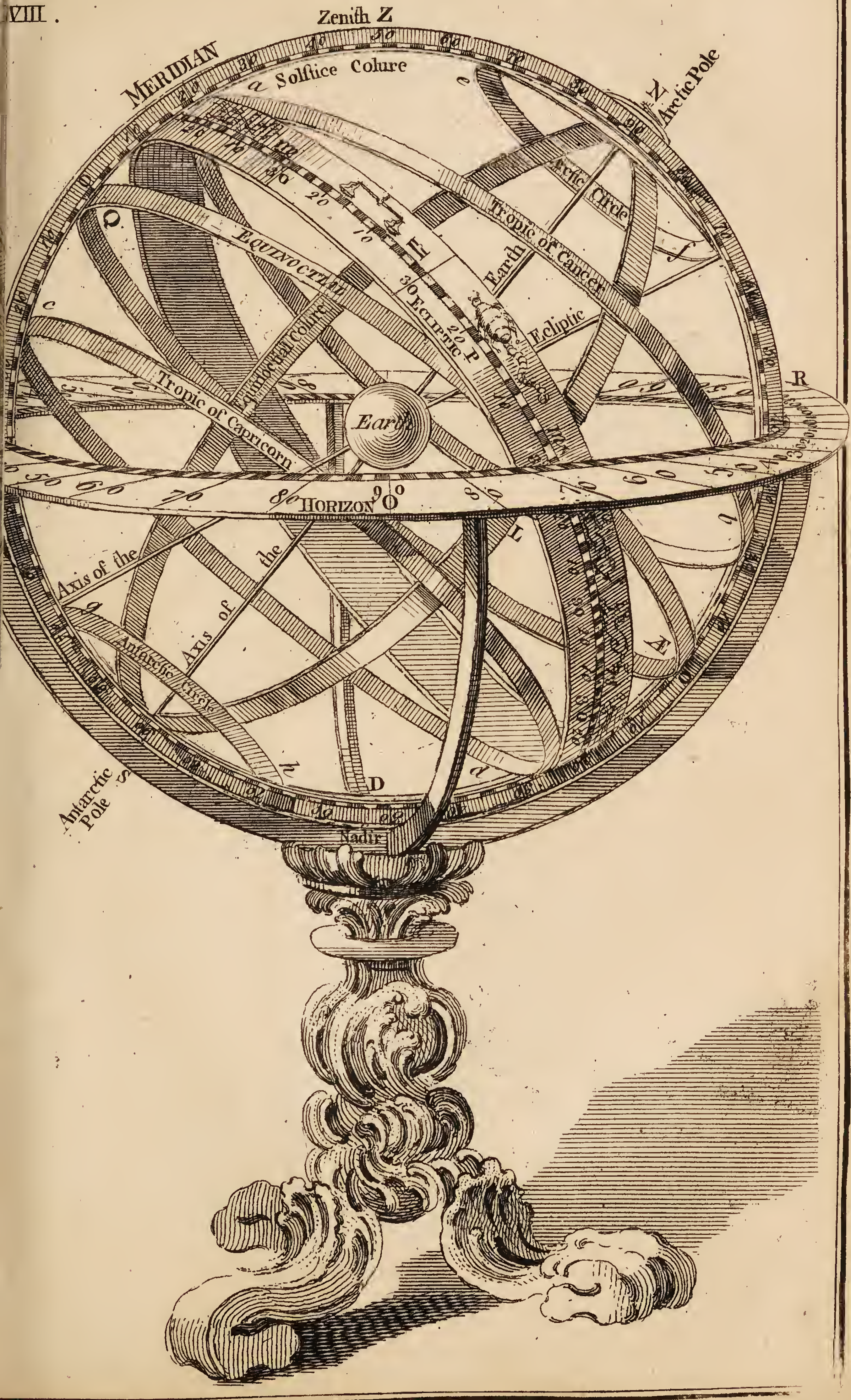
Euphroſ. Pray what is that you call the *Armillary Sphere?*

Cleon. I will preſently ſhew you; I have bought one at *London*, as I came home, which coſt me 20 Guineas, on Purpoſe to give you the better Idea of ſuch Things as may prove the future Subject of our Speculations.——Here it is, Siſter.

Euphroſ. A fine and curious Machine, indeed! But I ſee nothing

The Armillary Sphere

VIII.



thing but Circles variouſly connected together; pray, what am I to underſtand by them?

Cleon. You will ſee more hereafter; but we will firſt conſider the Nature and Uſe of the Circles; a due Underſtanding of which is the Ground of all practical Aſtronomy.

Euphroſ. That's doubtleſs the Caſe; but a Parcel of bare Circles ſeem an uncouth Subject for Study; they ſeem ſo variouſly combined and intermixed, that I fear I ſhall never underſtand them.

Cleon. So I remember you once ſaid of the various Conjugations and Kinds of Verbs in the *French Grammar*, and yet you have found, that nothing but Attention and Reſolution was neceſſary to make you a perfect Miſtreſs of them. The like you will find of this Study, which is much eaſier: I ſhall only repeat the Words of *Manilius*, to encourage you thereto.

A ſubtle and ſurpriſing Taſk is ſhown;
Much have I paſt, yet ſtill you lead me on.
Theſe Things ſeem dark, whilſt I the reſt explore,
Enjoy my Precepts, and complain no more.
'Tis God you ſearch for, by my Aid you try
To climb, and view the Inſide of the Sky;
Confin'd by Fate, you ſearch its boundleſs Sway,
And ſeek to know the Laws you muſt obey:
The narrow Bounds of your own Breaſt you paſs,
Enjoy the World, and rove in the vaſt Space:
Painful, but always noble Things are hard,
Great is the Taſk, but equal the Reward:
Nor let the various Maze thy Thoughts repreſs,
Enter, and you are certain to poſſeſs.

Book IV.

Euphroſ. I do not in the leaſt deſpond; I only wiſh your Patience, *Cleonicus*, may hold out with mine. To make a Beginning on this Inſtrument, therefore, pray tell me why it is called an *Armillary Sphere?*

Cleon. Becauſe of the various Circles of which it is compoſed, which are like ſo many *Rings* or *Hoops*, which in *Latin* are called *Armillæ* in general; though this Word properly ſignified a Bracelet, an Ornament formerly worn on the Arm, and given by Captains to their Soldiers, and by ſuch as held any Poſt, *&c.* Hence you ſee the Propriety of the Name.

Euphroſ. I do; and muſt next aſk you what this Sphere is deſigned to repreſent in general?

Cleon. This Sphere, by its real Circles, repreſents the imaginary Circles of the concave Expanſe of the Sky, by which Aſtronomers divide the Heavens into the ſame Parts or Portions, as you ſee theſe Circles divide the Sphere.

Euphroſ. I ſuppoſe you mean, if my Eye could be placed in the Center of this Sphere, I ſhould ſee its Circles upon, or againſt thoſe very Parts of the Heavens where thoſe imaginary Circles of the Aſtronomers are ſuppoſed to be.

Cleon. Moſt happily conceived, my *Euphroſyne*; your Genius is turned for the Science.—The Sphere you obſerve is moveable within the Frame, and the large Circle (H O) ſupported thereby; which Circle, you ſee, with ſome others, are graduated, or divided into their proper Degrees.

Euphroſ. I take notice of thoſe graduated Circles; but muſt confeſs I have but an imperfect Notion of thoſe Diviſions and their Uſes, and ſhould be glad to have them farther explained to me.

Cleon. To underſtand that aright is a fundamental Article; in order to which you muſt know, that a Circle is generally divided into four equal Parts or Quarters, called *Quadrants*, and each of theſe Quadrants is again divided into 90 equal Parts, called *Degrees*, as you ſee is done on this broad Circle; ſo that the whole Circle contains four Times 90, or 360 Degrees.—Again, each Degree is ſuppoſed to be ſubdivided into 60 equal Parts, called *Seconds*, and each Second into 60 others, called *Thirds*; and ſo on. But theſe laſt Diviſions are too ſmall to be actually made; and therefore a Degree is generally divided but into Halves and Quarters; that is, at every 15th Minute: But I have formerly acquainted you with this Manner of dividing a Circle, and need not again repeat it to my *Euphroſyne*.

Euphroſ. I underſtand you well, and thoſe Degrees, I ſee, are numbered at every 10th Diviſion; but I alſo obſerve, this Method of numbering Degrees is not the ſame in all the graduated Circles of this Sphere.

Cleon. No, it is not; but differs in almoſt all of them, according to their different Natue and Uſe.

Euphroſ. Pray, how many Kinds of Circles are there? And what are their Names?

Cleon. All the Circles of the Sphere are but of two Sorts, *viz. Great* and *ſmall Circles.* The *greater Circles* divide the Sphere into two equal Parts, or *Hemiſpheres*; and leſſer Circles divide it into two unequal Parts, or Segments.

Euphroſ. How many are the great Circles of the Sphere?

Cleon. They are in Number *ſix.* Four of which are graduated, *viz.*

1. The HORISON, (H O R) which is this broad Circle, ſupported by the Frame within which moves

2. The *General* MERIDIAN, (H Z R D) which is this upright, graduated Circle, ſtanding at right Angles to the Horizon; and within this moves the Sphere itſelf.

3. The EQUINOCTIAL, (Æ Q) which divides the Sphere into the *Northern* and *Southern Hemiſpheres.*

4. The ECLIPTIC, which is this large Circle, on which you ſee the Characters of the 12 Signs, and which cuts the *Equinoctial* in two oppoſite Points at the Horizon.—The other two are called COLURES; the firſt of which is called

5. The *Equinoctial* COLURE, which is the great Circle that paſſes through thoſe two Points of the Equinoctial, where the Ecliptic interſects it.

6. The *Solſtitial* COLURE, which is that great Circle you ſee juſt under the *General Meridian*; to which, and the other *Colure*, all the other Circles are fixed.

Euphroſ. So far I underſtand you very well: But now tell me which, and how many are the *leſſer Circles* of the Sphere?

Cleon. They are *four*, *viz.* Two *Tropic*, and two *Polar Circles.*

1. The *Tropic of Cancer*, (*a b*) which lies parallel to the *Equinoctial* on the North Side, at the Diſtance of 23½ Degrees, and touches the *Ecliptic* in the Beginning of *Cancer.*

2. The *Tropic of Capricorn*, *(d e)* which is ſituated, you ſee, at the ſame Diſtance from the *Equinoctial*, and parallel to it, on the South Side; touching the *Ecliptic* in the Beginning of *Capricorn*.

3. The *Arctic Circle*, *(e f)* parallel to the *Equinoctial* on the North, at the Diſtance of 66½ Degrees.

4. The *Antarctic Circle*, *(g h)* which, you ſee, is parallel to, and at the ſame Diſtance from the Equinoctial on the South Side.—And thus you have the Names of the principal Circles of the Sphere.

Euphroſ. I thank you, *Cleonicus:* But there is that ſtrait, curious Rod or Wire in the Middle of the Sphere, about which it turns; is it not what you call the *Axis of the Sphere?*

Cleon. Yes, *Euphroſyne*, it is; and it repreſents the Axis of the World, and the two Extremities thereof, (N and S) are called the *Poles* of the World; the former (N) the *North Pole*, which is above our Horizon; and the latter (S) the *South Pole*, below the Horizon.

Euphroſ. But this ſmall Circle, fixed on the Meridian about the North Pole, I preſume, you call the *Hour-Circle*; from the Hours I ſee engraved thereon, and the Hand on the Axle, pointing to them.

Cleon. You judge aright, 'tis called the *Hour-Circle*; and is rather an Appendage to the Sphere, than a Part of it: The Uſe of which, and of all the Circles of the Sphere, great and ſmall, we will more fully conſider, and apply, in the next enſuing Opportunities. The Day-light being too far gone to admit any Thing farther on this Subject at preſent.

DIALOGUE II.

Of the HORIZON, *and its various Uſes.*

Euphroſyne.

YOU gave me Yeſterday an Account of the Spheres, and the Names of the Circles which compoſe it, *Cleonicus*; I ſhall be glad to have a more diſtinct and particular Explanation of the Nature and Uſe of thoſe Circles, that I may the more compleatly comprehend the Deſign of the Machine.

Cleon. I'll now begin to inform you of the *Name*, *Nature*, and *Uſe* of all the Circles; how they divide the Sphere; and the Terms of ſeveral Points and Parts of the Machine derived therefrom.—And firſt of all, let us conſider this broadeſt Circle, the *Horizon*.

Euphroſ. With Pleaſure I attend you, *Cleonicus*; pray then, whence has it the Name? And what does it import?

Cleon. The Word is derived from the *Greek*, and the Uſe of the Circle is contained in its Name; for it comes from a Word which ſignifies to *bound*, *limit*, or *terminate*; as the *Horizon* is appointed to ſhew that Circle in the Heavens, which *bounds* or *terminates* the Sight of the Spectator any where ſituated on the Earth.

Euphroſ. I ſuppoſe you mean, that diſtant Boundary of our Sight, where the Heavens and the Earth ſeem to join all around us, as it appears from the Top of an high Mountain or Tower.

Cleon. The very ſame, *Euphroſyne*; 'tis that imaginary Circle which intercepts from our View the Sun, Moon, and Stars, each Night; and when they deſcend below it, we ſay, *they are ſet*; as on the contrary, each Morning, when they appear above it, we ſay, *they riſe*.

Euphroſ. How far is this Circle diſtant from us in the Heavens?

Cleon. It is every Way diſtant from the Point over our Heads in the Heavens juſt 90 Degrees; and therefore divides the Heavens into two equal Parts, called the *Upper* and the *Lower Hemiſpheres*.

Euphroſ. By the upper Hemiſphere, I ſuppoſe, you mean all that Part of the Heavens which is open to our View; and by the under or lower Hemiſphere, all that Part which is hid from our Sight.

Cleon. Very right, Siſter, I do: And the two Points, (Z and D) which are equally diſtant from the Horizon on every Part above and below it, are called the *Poles of the Horizon*; and further, this which is above it, (*z*) and over the Head of the Spectator, is called the *Zenith*, as that (D) which is under his Feet is called the *Nadir*. Of this great Circle *Manilius* thus ſings:

To find the ſpacious Line, caſt round thine Eyes,
And where the Earth's high Surface joins the Skies,
Where Stars firſt ſet, and firſt begin to ſhine,
There draw the fancy'd Image of this Line.
Which Way ſoe'er you move, 'twill ſtill be new;
Another Circle opening to the View;
For now this half, and now that half of Sky,
It ſhews its Bounds ſtill varying with the Eye.
This Round's terreſtrial, for its Bounds contain
That Globe, and cut the Middle with a Plain;
'Tis call'd the Horizon, *the Round's Deſign,*
For 'tis, to bound, *gives Title to the Line.*

Aſtron. Book I.

Euphroſ. The Poet intimates what I was juſt going to obſerve, *viz.* that this Circle muſt *always be variable and new*, according to the different Situation of the Spectator on the Surface of the Globe, or Sphere.

Cleon. Very true, *Euphroſyne*; every Perſon has an Horizon peculiar to himſelf. Thus the People of *Paris* have a different Horizon from that of the People at *London*, or *Madrid*; their viſible Hemiſphere extending more to the South than that of the former, and leſs than that of the latter. All which I ſhall more fully explain to you on the terreſtrial Globe.

Euphroſ. But, pray, what is this other Circle on the outer Part of the Horizon, marked all round with Letters?

Cleon. This Circle is called the *Compaſs*; it is of great Uſe at Sea; and alſo in the Sciences of Aſtronomy and Geography; for which Reaſon it is fixed on the Horizon of Spheres and Globes.

Euphroſ. What are thoſe various Diviſions in it, by which the Letters ſtand?

Cleon. They are called the *Points of the Compaſs*; and are 32 in Number, each containing 114 Degrees. Four of which are called the *Cardinal Points*, and are marked with the firſt Letter of their Names, *viz.* S, the *South*; W, the *Weſt*; N, the *North*; E, the *Eaſt*. Theſe four principal Points are ſometimes called the *four Winds of Heaven*. They divide the Horizon, you ſee, into four Quarters, in each of which are *eight Points*.

Euphroſ. What are the Names of theſe intermediate Points?

Cleon. They receive their Names from their relative Diſtances from the four Cardinal Points, in each Quarter reſpectively; which Names are denoted by the initial Letters alſo.

Thus in the Quarter between the *South* and *Weſt*, the Points are denominated as follows:

1.	S.	SOUTH.
2.	S. by W.	SOUTH by WEST.
3.	S. S. W.	SOUTH-SOUTH-WEST.
4.	S. W. by S.	SOUTH-WEST by SOUTH.
5.	S. W.	SOUTH-WEST.
6.	S. W. by W.	SOUTH-WEST by WEST.
7.	W. S. W.	WEST SOUTH-WEST.
8.	W. by S.	WEST by SOUTH.
	W.	WEST.

After the ſame Manner, you ſee, the Points in the other Quarters are named as denoted by the Capital Letters.

Euphroſ. I underſtand you perfectly well, as to that; but what is the Uſe of theſe Points?

Cleon. By them we uſually diſtinguiſh the Courſe of the Winds and Clouds, and give them their proper Names; thus if the Wind blows from the *North-Eaſt* Point, we ſay it is a *North-Eaſt Wind*; and the Courſe of the Clouds we ſay is *South-Weſt*, which is oppoſite to it.

Again, in Geography, we thereby diſtinguiſh and relate the *Situation* and *Bearing* of Places, Countries, or Cities, one from another: Thus, we ſay, *Bourdeaux* in *France* lies *South* of *London*; and *Bagdat* bears *South-Eaſt* from *London*.

Laſtly; in *Aſtronomy*, we ſay, the *Sun*, *Moon*, or *Planets*, riſe on ſuch or ſuch a Point; or ſo many Points from the *Eaſt* or *Weſt* toward the *South* or *North*; which Diſtance from the Eaſt or Weſt Point is called the *Amplitude of their Riſing or Setting.* I ſhall not mention the Uſe of the Compaſs at Sea, as yet.— Theſe are the chief Uſes that it ſerves for in common, and are ſummarily included in the following Verſes:

> *The* Compaſs-Points *by Art have been deſign'd,*
> *To ſhew the various Courſes of the Wind;*
> *From hence the Seaman, hence the Farmer knows,*
> *If* North, South-Eaſt, *or* South-South-Weſt *it blows;*
> *Whence they, or Calms, or Tempeſts, oft preſage,*
> *And ſhew their Skill in Heav'n's prophetic Page.*
> *Their Uſe in Geography doth hence appear,*
> *They ſhew from us how all the Countries bear;*
> *Of Towns from Towns the varied Site we learn,*
> *And Trav'lers hence the dubious Way diſcern.*
> *From hence, in Aſtronomic Phraſe, we ſay,*
> *On ſuch a Point* Sol *uſhers in the Day;*
> *Or ſets* Alderbaran; *or* Cynthia *bright,*
> *Drive* Weſt by South *the Chariot of the Night.*

Euphroſ. Well, I never knew ſo much of the *Compaſs*, and its Uſe, before; but I ſee now it is very conſiderable: If there remain any other Uſes of the Horizon, or Compaſs, which we have not enquired into, pray, let me know them, *Cleonicus.*

Cleon. What remains will be better explained when we come to Globes; at preſent we will proceed to the *General Meridian*, and conſider its Properties.

DIALOGUE III.

Of the GENERAL MERIDIAN, *and the* Degrees *of* Latitude.

Euphroſyne.

I Obſerve the Names of theſe Circles import ſomething of their Nature and Uſe; pray, what is implied by the Name of this Circle, the *Meridian?*

Cleon. It is derived of the *Latin* Word *Meridies*, which ſignifies *Mid-day*, or *Noon*; becauſe, when the Sun comes upon the Meridian of any Place, it is then Noon, or Mid-day, at that Place.

Euphroſ. Very good; but why do you call it the *General Meridian?*

Cleon. To diſtinguiſh it from *particular* Meridians: Now you muſt know, that a *particular*, or *ſpecial* Meridian is an imaginary Circle in the Heavens, which paſſes through the Poles of the World, and the Zenith Point of every Perſon whereſoever ſituated on the Earth's Surface: Conſequently, there will be as many ſuch Meridians as you can imagine Points from *Eaſt to Weſt*, all round the Earth; for thoſe which lie *North* and *South* of each other, have the ſame Meridian; becauſe theſe Circles lie North and South themſelves. Now, in Spheres and Globes, this general Meridian ſuffices for all the Reſt; for ſince it is fixed, and the Sphere or Globe is moveable about its Axis, you may by turning the ſame bring any different Part of their Surface under this Meridian, which will then repreſent the Meridian of that Part or Place.

Euphroſ. So the Office of this Meridian, I perceive, is vicarious, *viz.* to repreſent all, or any of the Reſt. Well, ſince you have let me into the Reaſon and Significancy of the Nature or Title, let me next know what theſe Diviſions or Degrees are upon it, and to what Uſe they ſerve.

Cleon. I will: You obſerve they begin at the Equinoctial, and proceed each Way to the North and South Pole of the World, to the Number of 90.

Euphroſ. I do; and pray what do you call them?

Cleon. They are called the Degrees of *Latitude*; by the Word Latitude you are to underſtand any *Diſtance*, *North or South* of the Equinoctial, towards the Poles; and becauſe ſuch a Diſtance of any Part of the Sphere or Place on the Globes is eſtimated by theſe Degrees, you will readily ſee the Reaſon of their Name.

Euphroſ. I do very plainly; but why are thoſe Degrees numbered a contrary Way on the other Half of the Meridian, or that under the Horizon? For they are reckoned from the Poles towards the Equinoctial there, I ſee.

Cleon. That's well obſerved, *Euphroſyne*; the Diviſions are there numbered a contrary Way, the Deſign of which is, that the *Height*, or *Elevation of the Pole* above the Horizon may be readily ſeen, in any Poſition of the Sphere; and this *Elevation of the Pole* is always equal to the Latitude of any Place on the Earth's Surface.

Euphroſ. I preſume you mean, that ſo many Degrees as any Place lies North or South from the Equinoctial, juſt ſo many Degrees will the North or South Pole appear above the Horizon of that Place. But how ſhall I be able to conceive the Truth of this?

Cleon. Very eaſily, if you conſider, that from the Equinoctial (Q) to the Pole (N) are juſt 90 Degrees; alſo from the given Place (Z) to the Horizon (R) are juſt 90 Degrees; but the Part between the Place and the Pole (Z N) is included in both thoſe equal Parts, and therefore, if it be ſubducted from both, the Remainders will be equal; that is, the Arch (Q Z) will be equal to the Arch (N R) or the Latitude (Q Z) of the Place (Z) is equal to the Height, or Elevation (NR) of the Pole (N).

Euphroſ. I believe I apprehend the Meaning; but, pray, *Cleonicus*, what would you infer from thence?

Cleon. A very important Uſe is made of this in divers practical Arts: Thus the *Geographer* and *Dialliſt*, by taking the Height of the *Pole Star* with a good Quadrant, know the Latitude of the Place; by this Means alſo, the Sailor finds his Latitude at Sea; hence likewiſe we have a ſpeedy Method of rectifying a Sphere, or Globe, as we ſhall farther ſee by and by.

Euphroſ. What farther Uſes are made of this great Circle?

Cleon. By Means thereof, we alſo meaſure the Diſtances of the Sun, Planets or Stars from the *Equinoctial*, North or South; and the Degrees, or Diſtance of this Sort, are called the *Declination of thoſe Bodies from the Equinoctial.* ——— Thus ſuppoſe the higheſt or moſt Northern Part of the Ecliptic be brought to the Meridian,—you ſee it cut the ſame in 23½ Degrees; and ſo much is the Declination of that Point:—Which you ſee is the ſame alſo on the South Side. The Declination alſo of the Polar Circle you obſerve is 66½ on each Side the Equinoctial.

Euphroſ. I do ſo; and have now gotten a pretty good Notion of *Latitude* and *Declination*. But, pray, what is the Uſe of this thin, long Slip of Braſs, which I ſaw you at firſt take off from the Meridian?

Cleon. It is called the *Quadrant of Altitude*; becauſe it is juſt a Quarter of a Circle, and divided into 90 Degrees; and being fixed on the higheſt, or vertical Point of the Meridian (Z) reaches to the Horizon all around; and being moveable on a Pin at the Meridian, it may be carried to any Part on the Sphere or Globe; and ſo will ſhew the Height or Altitude of the Sun, or any Star above the Horizon, at any Time, or in any Poſition of the Sphere. Alſo being laid over any Place, it ſhews how that Place bears from you by the Points of the Compaſs on the Horizon. Alſo, by this you will be taught how to meaſure, in Degrees, the Diſtance of any two Places on the terreſtrial Globe, or of any two Stars in the celeſtial. The graduated Edge of this Quadrant repreſents on the Globe thoſe imaginary Circles, which the Aſtronomers call *Azimuths*, or *Circles of Altitude*, and is a Kind of *general Azimuth*, as this, a *general Meridian*. But, enough of this Circle, till we come to the practical Part on the Globes; and ſhall leave it with the poetical Deſcription, which *Manilius* has given of it, as follows:

——————— This from the Bear
Deſcrib'd, ſurrounds the Middle of the Sphere;
Divides the Day, and marks exactly Noon,
Betwixt the riſing and the ſetting Sun:
The Signs it changes as we move below,
Run Eaſt or Weſt, it varies as you go;
For 'tis that Line, which Way ſoe'er we tread,
That cuts the Heav'n exactly o'er our Head,
And marks the Vertex; which doth plainly prove,
That it muſt change as often as we move.
Not one Meridian can the World ſuffice,
It paſſes thro' each Portion of the Skies;
Thus, when the Sun is dawning o'er the Eaſt,
'Tis their ſixth Hour, and ſets their ſixth at Weſt;
Tho' thoſe two Hours we count our Day's Extremes,
Which feebly warm us with their diſtant Beams.

DIALOGUE IV.

Of the EQUINOCTIAL, *and the* DEGREES *of* LONGITUDE.

Euphroſyne.

THE next Circle then, *Cleonicus*, which you are to inſtruct me in the Knowledge of, is the *Eqainoctial:* I ſhall here, as before, deſire to be informed of the Reaſon of the Name.

Cleon. To underſtand this well, you muſt remember, as I told you, that this great Circle ſurrounds the Sphere, exactly in the Middle, or at equal Diſtance from the Poles of the World; and, ſecondly, you muſt obſerve, that the Ecliptic, which repreſents the Sun's Way, cuts this Circle in two oppoſite Points, and therefore of Courſe, the Sun is twice in the Year upon this Circle; and ſince one Half of this Circle is always above the Horizon, and the other Half below it, it comes to paſs, that, when the Sun is in thoſe two Points, the *Days and Nights will then be equal*, which is implied by the Name *Equinoctial.* For the ſame Reaſon alſo, thoſe two Points are called the *Equinoxes*, or *Equinoctial Points.*

Euphroſ. Very good: Pray, has this Circle any other Name?

Cleon. Yes; upon this Sphere, and the celeſtial Globe, it is called the *Equinoctial*; but on the terreſtrial Globe, it is called the *Equator*; becauſe it *equates*, or divides the Globe of the Earth into *two equal Parts*, *or Hemiſpheres*, as I ſaid: It is alſo called the *Equator* in all *Maps*, and *Sea-Charts.*

Euphroſ. I am glad I know that; for I would not (though a Woman) ſpeak improperly in naming this, or any other Part of the Sphere, or Globes. But what is the proper Uſe of this Circle?

Cleon. It is, you ſee, divided into 360 Degrees, beginning and ending in the *Equinox* Point, and numbered from Weſt to Eaſt at every tenth Degree. Theſe Degrees are called the *Longitude*, on the terreſtrial Globe; and on the celeſtial Globe and Sphere, they are called *Degrees of Right Aſcenſion.*

Euphroſ. I have heard much Talk of the *Longitude*, and have as little Knowledge of it, after all, as though I had never heard it mentioned: But as we are now come to the Circle of Longitude, I preſume you can give me a better Idea of that Matter.

Cleon. The *Longitude of a Place* is the Diſtance thereof, reckoned in Degrees of the *Equator*, from that Point of the Equator where the Degrees begin; and the Meridian, which paſſes through this Beginning of Longitude, is called by the Geographers, the *firſt Meridian.* Now, ſuppoſe the firſt Meridian be that of the City of *London*, as it is upon the beſt Globes, then the Arch of the Equator, contained between this and the Meridian of any other Place, is ſaid to be the *Longitude of that Place from London*; which you will learn with Eaſe to find, when we come to the Problems of the Globe.

Euphroſ. Then I underſtand, that as the Latitude of a Place is its Diſtance, *North* or *South* of the Equator, reckoned on the general Meridian; ſo the *Longitude* of any Place is its Diſtance, *Eaſt* or *Weſt*, from the firſt Meridian, reckoned on the Equator.

Cleon. You apprehend it very well, *Euphroſyne*; it is ſo; and the ſame Thing which on the terreſtrial Globe and Maps is called Longitude, is, on the celeſtial Globe and Sphere, called *Right Aſcenſion*; for with reſpect to the *Sun*, *Planets*, and *Stars*, their Diſtance Eaſtward is alſo counted on the Equinoctial, from a firſt, or fixed Meridian, and it is that paſſes through the Equinox (Q) where the Graduation begins; ſo that the Meridian, paſſing through the Sun or any Star, ſhews on the Equinoctial the Degrees of its *Right Aſcenſion*, or Diſtance from the Equinoctial Point: But with reſpect to the Ecliptic, their Diſtance is called *Longitude*, and is reckoned from a very large, bright Star in the Conſtellation, *Aries*, which Star I ſhall ſhew you hereafter, both on the Globe, and in the Heavens.

Euphroſ. But why is their Longitude reckoned from that Star, and not from the Beginning of the Ecliptic, as their *Right Aſcenſion* is?

Cleon. Becauſe this Star was formerly near the Meridian of that Point, yea, almoſt in the Equinox itſelf, at the Time of *Hipparchus*, about 2000 Years ago; ſince when, it has moved forward (with the ſlow Motion of the Stars I formerly mentioned to you) about 29½ Degrees; or elſe the Equinoxes have moved ſo much backward; and this Motion of the Equinoxes backward, makes the Sun enter thoſe Points ſooner every Year by nearly 20 Minutes, and this makes what you will find in Books of Aſtronomy is called the *Preceſſion of the Equinoxes.*

Euphroſ. Well, I think I underſtand now what you call the *Longitude*, and *Right Aſcenſion*, of the Planets and Stars: Pray, to what other Purpoſe does this Circle ſerve?

Cleon. I have already told you, that the Diſtance of the Sun, Planet, or Star, from the Equinoctial, North or South, is called its *Declination*: Beſides, the Degrees of the Equinoctial are convertible into Time, and ſhew in what Time any Part of a Revolution of the Sphere, or Globe, is performed.

Euphroſ. This, I ſuppoſe, is done by means of the Hour-Circle, and Hand, which is fixed about the North Pole.

Cleon. You judge right; for that Circle being fixed about the Axis, and the Hand, or Index, upon the Axis, and the Axis itſelf being fixed to the Circle at each Pole, it muſt follow, that, if the Sphere be moved, or revolved round its Axis, the Axis will alſo be revolved, and ſo carry the Index round upon the Hours engraved on the Circle.

Euphroſ. I obſerve, that on the Circle the 12 Hours are twice engraved; pray, why is that?

Cleon. The firſt 12 Hours ſhew the Time from Noon till Midnight; the laſt from Midnight to Noon the next Day; for you muſt know the *Aſtronomers begin the Day at Noon*; therefore the two Hours of XII. ſtand exactly upon the graduated Edge of the general Meridian.

Euphroſ. Well, now, *Cleonicus*, tell me how you find the Time in which any Motion is perform'd.

Cleon. I will; and firſt, you obſerve, I bring the Beginning of the Degrees, or Equinoctial Point, to the Meridian. Secondly, I then (holding the Sphere in that Poſition) turn the Index about to the Hour of XII. upon the Edge of the Meridian next to us. Thirdly, then you obſerve, I turn the Sphere once round, till the ſaid Point comes again to the Meridian, and the Index paſſes once round the Hour-Circle, which ſhews, that *one Revolution of the Sphere is performed in twenty-four Hours Time.*

Euphroſ. That is extremely eaſy to underſtand; and how then?

Cleon. If one Revolution, or 360 Degrees, be made in 24 Hours, then half a Revolution, or 180 Degrees, is made in 12 Hours; a Quarter, or 90 Degrees, in ſix; and in that Proportion 15 Degrees of the Equinoctial paſſes the Meridian in one Hour; and 15 Minutes, or one-fourth of a Degree, in one Minute of Time; which Notions of Motion and Time it will be neceſſary for you to have a clear Idea of, inaſmuch as they are the Grounds of many Problems on the Globes, which you will think very curious and diverting.

Euphroſ. I am obliged to you thus to prepare me with ſuch previous Knowledge for a right underſtanding of the Globes, towards which my Inclinations are very ſtrong.

Cleon. We'll make the Introduction to them as ſhort as can be; and to that End we ſhall dwell no longer on the Equinoctial here; which Circle, *Manilius* thus deſcribes.

The Equinoctial in the Midſt divides
The Sphere, and ſees the Pole on both its Sides.
And there, when Phœbus *drives, he ſpreads his Light*
On all alike, and equals Day and Night:
For in the Midſt he does the Heav'ns divide,
And cheers the Spring, *and warms the* Autumn's *Pride.*
And this large Circle drawn from Cancer's *Flame,*
Twice twelve Degrees divides the ſtarry Frame.

Creech's Man. *Lib.* I.

DIALOGUE

DIALOGUE V.

Of the ECLIPTIC, *and the* Longitude *of the* Heavenly Bodies.

Cleonicus.

WE are now come to the great Circle, called the *Ecliptic*; becauſe (as I formerly told you) all the Eclipſes happen in, or very near it; for this great Circle repreſents the Sun's apparent annual Path, or Tract, through the Heavens; and therefore, whenever the Moon obſcures the Sun, or is eclipſed by him, it muſt be when ſhe is in, or near this Line.

Euphroſ. This I underſtand; as alſo I remember you told me, this Circle was divided into 12 Parts, or Signs, whoſe Names and Characters you explained, and are ſuch as I ſee here engraved: But, pray, what was the Reaſon of ſuch a Diviſion of the Ecliptic?

Cleon. For the greater Eaſe and Readineſs of judging of, and expreſſing the Places of the Sun, Moon, and Planets, at any Time; for we can form a more diſtinct Idea of this in the Parts of a Sign, than in Parts of the whole Circle; the minute Parts of ſo grand a Whole, as the Circumference and Expanſe of the Heavens, obliged Aſtronomers to make various Diviſions of the celeſtial Circles, and to range the irregular Diſtribution of Stars in the Surface of the Skies, into certain and determinate Claſſes of Conſtellations, the better to reduce the Science to Order and Method.

Euphroſ. To be ſure Regularity and Method helps our Conception of Things very much. I can better apprehend in what Part of the Heavens the Sun, *&c.* is, when it is ſaid, he is in ſuch a Degree of ſuch a Sign, than I ſhould otherwiſe been able to have done. But what other Uſes do they make of the Ecliptic?

Cleon. By the Ecliptic they eſtimate the *Longitude*, *Latitude*, and *Declination* of the heavenly Bodies.

Euphroſ. How is the *Longitude* of theſe Bodies reckoned?

Cleon. It is eſtimated in Signs and Degrees of the Ecliptic, beginning from the firſt Minute of *Aries*, *viz.* in the Equinoctial Point (Q). Thus, ſuppoſe the Sun be now in the fifth Degree of *Leo*, ♌, we ſay, *his Longitude is four Signs*, *four Degrees*, *and Part of another*; for he has already paſſed the four Signs, *Aries*, *Taurus*, *Gemini*, and *Cancer*, and four Degrees of *Leo*, and is in the fifth.

Euphroſ. Very good; but the Sun is always in the Ecliptic; pray, how do you compute the Longitude of Planets and Stars, which are not *in*, but at a Diſtance *from* the Ecliptic on either Side?

Cleon. In this Caſe, their *Places are reduced to the Ecliptic*, by means of the Quadrant of Altitude fixed to the Braſs Meridian upon the Pole of the Ecliptic, which then repreſents a Circle of Longitude: To do this will be a Problem you will be taught on the celeſtial Globe.

Euphroſ. Well, and how do you eſtimate the Latitude of the heavenly Bodies?

Cleon. Their Latitude is reckoned in an Arch of the Quadrant of Altitude (fixed as aforeſaid) contained between the Planet, or Star, and the Ecliptic; that is, it is their Diſtance from the Ecliptic on either Side, meaſured upon a Circle of Longitude, which the Quadrant then repreſents; for Circles of Longitude are, with reſpect to the Ecliptic, the ſame as Meridians with reſpect to the Equinoctial, *viz.* they paſs thro' its Poles, and cut it at right Angles.

Euphroſ. As for the *Declination* of the Sun, or Stars, you have told it me occaſionally ſo often, that I can't forget it.—— Pray, what is the broad Circle you called the *Zodiac*, of which you gave me ſome Account, when we were conſidering the Theory of the Earth?

Cleon. That Circle, or rather Zone, is put upon ſome Spheres, but not upon Globes; it anſwers no great Purpoſe upon the Sphere, or Globe, inaſmuch as it repreſents only the Space or Limits to which the Planets ſtray on each Side the Ecliptic, which is about five Degrees; ſo that the Breadth of this Belt is 10 Degrees, as I then told you; and therefore upon this broad Circle, which you obſerve in this Sphere, are engraved the Figures of all the Animals of the 12 Signs; it ſerves to few other Purpoſes but for Ornament, and to inhance the Price of the Machine. The Zodiac and Ecliptic are thus deſcribed by *Manilius*,

Two more oblique, and which in adverſe Lines
Surround the Globe, obſerve: One bears the Signs,
Where Phœbus *drives, and guides his fiery Horſe,*
And varying Luna *follows in her Courſe.*
Where Planets err, as Nature leads the Dance,
Keep various Meaſures, undiſturb'd by Chance;
Its higheſt Arch with Cancer'*s Beams do glow,*
Whilſt Caper *lies, and freezes in the low:*
Twice it divides the Equinoctial Line,
Where fleecy Aries, *and where* Libra *ſhine.*
Three Lines compoſe it, and th' Ecliptic'*s found*
I' th' Midſt; *and all decline into a Round.*
Nor is it hid, nor is it hard to find,
Like others, open only to the Mind;
For like a Belt, with Studs of Stars, the Skies
It girds and graces, and invites the Eyes:
To twelve Degrees its Breadth, to thrice threeſcore
Its Length extends, and comprehends no more.
Within theſe Bounds the wand'ring Planets rove,
Make Seaſons here, and ſettle Fate above.

Creech. Lib. I.

Euphroſ. Do not the Aſtronomers diſtinguiſh theſe Signs into different Sorts, or Orders?

Cleon. Yes, and the Aſtrologers too. The Aſtronomers divide them into the *Summer* and *Winter Signs*. The *Summer Signs* are thoſe ſix which make the upper Half of the Ecliptic, or which lie above the Equinoctial, towards the North, *viz. Aries, Taurus, Gemini, Cancer, Leo,* and *Virgo*; for while the Sun is in them, it makes our *Summer*. The other ſix, which make the lower Half of the Ecliptic, are called *Winter Signs* for the ſame Reaſon.

Euphroſ. Pray, how do the Aſtrologers divide the Signs?

Cleon. They, according to their uſual Abſurdity and Cant, make them of various Kinds, and aſcribe to them wonderful Influences and Virtues. Thus, *Manilius* tells us ſome are *Male*, others *Female* Signs; ſome *Human*, others *Brute*:

Some Signs bear human Shape, *and ſome expreſs'd*
In ſingle Figures, bear the Form of Beaſt.

Some Signs are *ſingle*, others *double*, as *Gemini* and *Piſces*:

Thoſe Signs are ſingle; now obſerve the Pairs;
For double Shapes give double Force to Stars,
And each Companion ſtill in each creates
A Change, and vaſt Variety of Fates.

Some Signs are of different Species, as *Capricorn*, and *Sagittarius*:

Such is the Goat, *he twiſts a ſcaly Train,*
The Centaur *ſuch, half* Horſe, *and half a* Man.

Some Signs belong to the Day, others to the Night:

Yet ſwift, my Muſe, like Lark on tow'ring Wings,
Mounts to the Skies, and as ſhe mounts ſhe ſings;
She ſees Signs various in her ai'ry Flight,
Some which the Day *reſpect, and ſome the* Night.

Some Signs govern the *Water*, others the *Land*:

Some Signs, 'tis obvious, do the Sea *command,*
And others claim Dominion o'er the Land.
Thus wat'ry Piſces, *and the* Crab *retain*
Their proper Nature, both, and rule the Main.
The Bull *and* Ram *poſſeſs their old Command;*
They lead the Herds, and ſtill they love the Land.

Some they reckoned *fruitful*, and others *barren* Signs:

The Crab *is fruitful, and a numerous Brood*
Fierce Scorpio *yields, and* Piſces *fills the Flood;*
The Lion's *barren, and no Vows can gain*
The Maid; Aquarius *ſpends his Youth in vain.*
Ah! too remov'd, too far disjoin'd to prove,
The fruitful Pleaſures of encreaſing Love!

Beſides theſe, there are various other Diſtinctions made of the Signs, not one Jot leſs whimſical; as you will find in *Manilius*'s ſecond Book of his poetical Aſtronomy and Aſtrology. But leaving the Dreams and vain Imaginations of the Ancients, let us proceed to the Circles which remain.

Euphroſ. With a very good Will, *Cleonicus*; let the little Time we have be ſpent to the Purpoſe; I had rather be poſſeſſed of a little Sterling Science, than all the Parade of trumpery Nonſenſe.

DIALOGUE VI.

Of the COLURES, TROPICS, POLAR-CIRCLES, *and the* POLES *of the* WORLD.

Cleonicus.

THE next Circles we are to conſider, in the Sphere, are thoſe two called the *Colures*, both which paſs through the Poles of the World, and cut the Equinoctial at right Angles.

Euphroſ. And one of them paſſes thro' the Equinoctial Points, I obſerve.

Cleon. It does ſo; and therefore it is called the *Equinoctial Colure*; the other, which paſſes thro' the Beginning of *Cancer*, is called the *Solſtitial Colure.*

Euphroſ. Whence hath it that Name?

Cleon. From hence, that when the Sun, in his annual Courſe, comes near to the Beginning of theſe Signs on either Side, he ſeems to move neither Northward nor Southward for ſome Time, but as it were to be ſtationary, which Standing ſtill of the Sun, is in the *Latin* called *Solſtitium*, whence theſe two Points are called the *Solſtices*.

Euphroſ. What Diſtinction is made of theſe Solſtitial Points?

Cleon. Becauſe the Sun, when it is in the Beginning of *Cancer* makes *Midſummer*, that Point is called the *Summer Solſtice*; thus the other Point is called the *Winter Solſtice*; becauſe, when the Sun is in it, it is then *Mid-winter*.

Euphroſ. And have not the other Points, which you call the *Equinoxes*, in which the other *Colure* cuts the Ecliptic, ſome diſtinct Denomination from the Seaſons alſo?

Cleon. Yes; for when the Sun is in the Beginning of *Aries*, it is then the Middle of the *Spring*, which in *Latin* is called *Ver*, and therefore this Equinox is called the *Vernal Equinox*; and when the Sun is in the other Equinox, it is the Middle of *Autumn*, which therefore is called the *Autumnal Equinox*.

Euphroſ. Then theſe two *Colures*, I perceive, are, in a Sort, the Boundaries of the Year.

Cleon. That is their Office; they each of them point out two oppoſite Seaſons by their two oppoſite Parts upon the Ecliptic. And theſe are the two moſt notable Meridians of thoſe that are fixed; and the *Solſtitial Colure* has this in particular, that it alſo paſſes through the Poles of the Ecliptic, and therefore cuts it alſo at right Angles. Of theſe Circles *Manilius* has given us this general Deſcription.

From Pole all round to Pole *two Lines expreſs'd,*
Adverſely drawn, which interſect the Reſt,
And one another: They ſurround the Whole,
And croſſing, make right Angles at each Pole.
Theſe into four *juſt Parts divide the Sphere,*
And mark by Signs *the* Seaſons *of the Year.*

After this, he gives us a particular Deſcription of each *Colure*, and of their Courſe thro' the various Conſtellations of the Heavens: And firſt of the Equinoctial *Colure*——

One drawn from Heav'n's high Top, deſcends from far,
And cuts the Serpent's *Tail, and the dry* Bear:

The Equinoctial Scales, *the* Snake'*s Extremes*,
And next the Southern Centaur'*s middle Beams*;
Then thwarts the adverſe Pole, and next divides
The mighty Whale, *and parts its ſcaly Sides.*
Bright Aries *Point, and ſplendid* Trigon *paſt*
The fair Andromeda *below the Waſte*;
And next her Mother's Head it cuts, and then
The Pole, *and cloſeth in itſelf agen.*

Then of the *Solſtitial Colure* ——

Croſs this, and from the Pole doth firſt appear
The other, thro' the Fore-feet of the Bear,
And thro' its Neck; which, when the Sun retires,
Firſt ſhines, and ſpreads black Night, with feeble Fires,
Then parts the Twins *and* Crab, *the* Dog *divides,*
And Agro'*s Heel, that broke the frothy Tides.*
And then the Pole, and other Circle croſt,
To Caper *turns, contracted in his Froſt:*
The Eagle *cuts, and the inverted* Lyre,
Black Draco'*s Folds* ————————
The hinder Paws o' th' Bear, *and near the Pole*
Its Tail; and cloſing there compleats the Whole.
Theſe Rounds immovable, their Site the ſame,
Here Seaſons fix, nor vary in the Frame.

Lib. I.

Thus much, at preſent, is ſufficient concerning the *Colures*; let me now proceed to the *Tropics*.

Euphroſ. Why are thoſe two Circles called the *Tropics*, *Cleonicus?*

Cleon. To underſtand the Reaſon thereof nicely, you muſt know, (which you will eaſily obſerve) that while the Sun is going from *Aries* to *Cancer*, he advances every Day more Northward than before he was, till being come to *Cancer*, he is moſt northerly that he can be; after which, as he deſcends to *Libra*, he gets every Day more Southward than before. Now, when he is in the Beginning of *Cancer*, it is, that he changes his Motion,

tion, and *turns* from going Northward to go Southward: Now this *Turning back* of the Sun was by the *Greeks* called *Trope*; from whence the Parallel paſſing thro' the Beginning of *Cancer* is called the *Tropic of Cancer*.

Euphroſ. Very good, I underſtand you well; and I ſee alſo the ſame Reaſon, why the other is called the *Tropic of Capricorn*, becauſe there the Sun *returns* from the ſoutherly Courſe to his northern one. But, pray, what is repreſented by theſe Tropics on the Sphere?

Cleon. Theſe Tropics repreſent (for any Latitude) the *longeſt* and *ſhorteſt Days in the Year*; for they ſhew the Part of the diurnal Motion of the Sun for the two Days when he is in the Beginning of *Cancer* and *Capricorn*; where he has the greateſt and leaſt *Meridian Altitude*; and conſequently, when he is in the firſt Minute of *Cancer*, all that Part of the Tropic of *Cancer*, which is above the Horizon, repreſents the Length of that Day; and all that is beneath the Horizon repreſents the *Night* of that Day; and it is eaſy to obſerve, from the Sphere, that that Day is the *longeſt*, and that Night the *ſhorteſt* of all others in the Year. In the ſame Manner, the two Parts of the Tropic of *Capricorn*, above and below the Horizon, ſhew the *ſhorteſt Day* and *longeſt Night* in the Year.

Euphroſ. I believe I apprehend your Meaning tolerably well; but you muſt make ſome Grains of Allowance to a Novice in theſe Studies.——Pray, have theſe Tropics any other Uſe?

Cleon. They are the Boundaries between the *Torrid* and *Temperate Zones*, of which more hereafter. The *Tropic of Cancer* is thus poetically deſcribed by *Manilius*:

The Line deſcrib'd thro' Cancer's *Claws confines*
The utmoſt Limits of the fatal Signs;
There, when the Sun aſcends his greateſt Height,
In largeſt Rounds he whirls the Day and Night;
Pleas'd with his Station, there he ſeems to ſtay,
Nor lengthens much, nor much contracts the Day.

And the *Tropic of Capricorn* thus;

Another, Southward drawn, exactly ſets
The utmoſt Limits to the Sun's Retreats;
When hoary Winter calls his Beams away,
Obliquely warms us with a feeble Ray,
And whirls, in narrow Rounds, the freezing Day.
To us his Journey's ſhort, but where he ſtands,
With Rays direct he burns the barren Sands.
To wiſh'd-for Night he ſcarce reſigns the Day,
But in vaſt Heats extends his hated Sway.

Lib. I.

We are now come to the *Polar Circles*, which are the laſt to be conſidered on the Sphere.

Euphroſ. Theſe, I remember, you told me were called the *Arctic* and *Antarctic* Circles; pray, whence do they derive theſe Names?

Cleon. The *Arctic* Circle, or that about the *North Pole*, is ſo called from *Arctus*, the *Greek* Name of the Conſtellation of the greater *Bear*, which is ſituated very near it; and the North Pole is ſometimes called the *Arctic Pole*, becauſe it is the laſt Star in the Tail of the leſſer *Bear*; as I ſhall ſhew you hereafter, when we come to diſcourſe of the Conſtellations. The other is called the *Antarctic* Circle, as being on the *oppoſite Part* of the Sphere to this.

Euphroſ. What is the Uſe of theſe Circles?

Cleon. They ſhew the Latitude on each Side the Equinoctial, where the Sun does not ſet, or go below the Horizon, when he is at the greateſt Diſtance, North and South, that is, in the Beginning of *Cancer* and *Capricorn.*

Euphroſ. Indeed! is there ſuch a Thing as all Day, and no Night, in that Latitude?

Cleon. Yes; and the nearer you go from the Polar Circle to the Pole, the longer the Sun continues above the Horizon; and preciſely under the Pole, the Sun ſets not for the Space of ſix Months, or half a Year, as I ſhall demonſtrate to you on the Globes hereafter; and the other half Year it is all Night; that is, the Sun is not ſeen from that Pole above the Horizon, which in that Caſe is the Equator itſelf.

Euphroſ. This is very wonderful; I hope I ſhall underſtand you better upon the Globes. — But, what other Uſe do you make of theſe Circles?

Cleon. They are the Boundaries between the *Temperate* and *Frigid Zones.* Theſe Circles alſo *Manilius* thus deſcribes:

> *One tow'rds the North ſuſtains the* ſhining Bear,
> *And lies divided from the* Polar Star
> *Twice twelve Degrees, and thirty Minutes leſs;*
> *Which Space the Tropics from the Line poſſeſs.*

The *Antarctic* thus:

> *The laſt, drawn round the ſouthern Pole, confines*
> *Thoſe* Bears, *and lie, the utmoſt of the Lines.*
> *Wiſe Nature conſtant in her Work is found,*
> *Wide as the* Arctic *is th'* Antarctic *Round.*

Euphroſ. But before we leave this Subject, pray tell me one Thing; why are the Ends of the Axis of the Sphere called the POLES *of the World?*

Cleon. The Word *Pole* is *Greek*, and ſignifies to *turn round about:* Now, ſince theſe two Points in the Heavens, which are oppoſite to the Ends of the Axis of the Sphere, are quieſcent, and all the other Parts of the Heavens have an apparent Motion about them, therefore they were looked upon as the two great *Cardinal Points*, or *Hinges*, on which the whole Fabric of the World did turn.

Euphroſ. I think the Deſcription of theſe Poles in *Virgil* is very fine, when he ſays,

> *Two Poles turn round the Globe, one ſeen to riſe*
> *O'er* Scythian *Hills, and one in* Lybian *Skies;*
> *The firſt ſublime in Heav'n, the laſt is whirl'd*
> *Below the Regions of the nether World;*
> *Around our Poles the ſpiry* Dragon *glides,*
> *And, like a wandring Stream, the* Bears *divides,*
> *The leſs and greater, who by Fate's Decrees,*
> *Abhors to dive beneath the ſouthern Seas;*

There, as they ſay, perpetual Night is found,
In Silence brooding on th' unhappy Ground:
Or when Aurora *leaves our northern Sphere,*
She lights the downward Heav'ns, and riſes there;
And when on us ſhe breathes the living Light,
Red Veſper *kindles there the Tapers of the Night.*
Dryden's Virgil.

But does he not here aſcribe a Motion to the Poles themſelves?

Cleon. He does; and by it only means, that when we go North or South, they *appear to aſcend or deſcend*, above or below the Horizon; at leaſt, this is all the Motion the Poles can poſſibly have. But more of this when we come to the Uſe of the Globes.

Thus have we paſſed through ſo much of the Doctrine of the Sphere, as is neceſſary to enable you to have a right Underſtanding of the *Globes* and *Orrery*, which will exemplify and illuſtrate all thoſe Matters, and make them familiar and eaſy to your Apprehenſion.

Euphroſ. Dear *Cleonicus*, you highly oblige and delight me; I think long e'er thoſe Inſtruments come in Play: Pray, which are we to have next, the *Globes*, or *Orrery?*

Cleon. The Orrery, my *Euphroſyne*; I have provided one for that Purpoſe, which will afford you a pleaſurable Entertainment for the next Leiſure-Hours.

DIALOGUE VII.

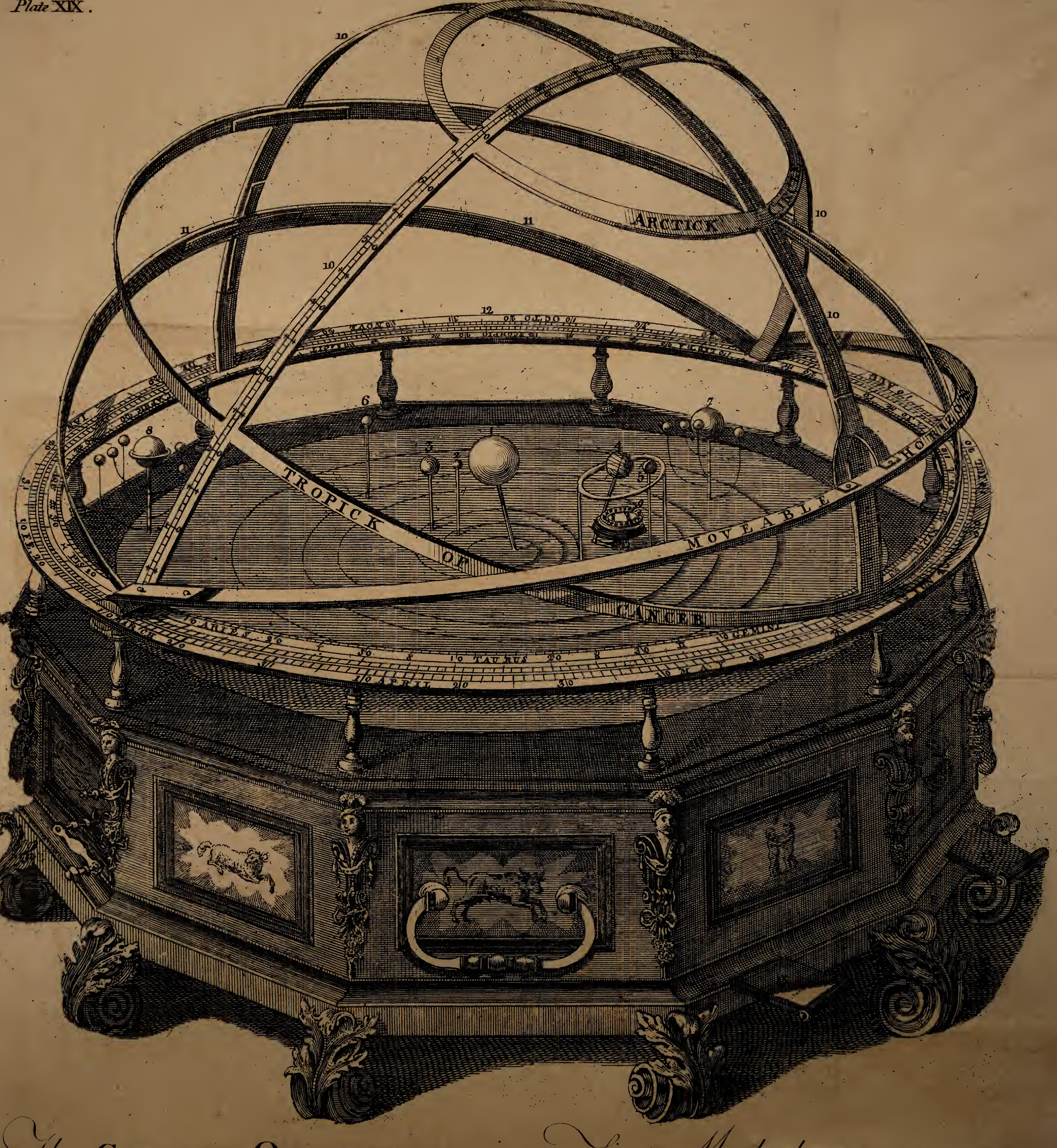
Of the ORRERY.

Cleonicus.

YES, my *Euphroſyne*; this is the famed Machine, of which I promiſed you the Sight and Uſe, when we laſt converſed on theſe Subjects.

Euphroſyne.

Plate XIX.



The GRAND ORRERY as it was first Made by Mr. Rowley.

Euphroſ. A glorious Piece of Art it ſeems to be, indeed! Pray, who was the firſt Inventor of it?

Cleon. This Machine was invented by Degrees, and made in its utmoſt Perfection, firſt by Mr. *Rowley*, for King *George* the Firſt; after which the Earl of *Orrery* beſpoke another; and from him, it is ſuppoſed by ſome, that it had its Name: But ſome will have it derived from a *Greek* Word of the ſame Sound, which ſignifies *to ſee*; becauſe in this Machine *we ſee all the Motions* of the heavenly Bodies performed in the ſame Manner as they are in Nature itſelf.

Euphroſ. Are there not different Sorts of Inſtruments of this Kind made; becauſe, I think, I have ſeen the Cut of an Orrery, of a different Make from this?

Cleon. Yes; ſince the firſt Invention they have been variouſly made, and very much improved by ſeveral Artiſts, particularly Mr. *Rowley*, and Mr. *Wright*; Dr. *Deſaguliers* alſo contrived a curious Machine of this Sort, which he called the *Planetarium*; alſo there has been made another Inſtrument, called the *Aſſimilo*; but the Orrery conſtructed by the late ingenious Mr. *Dean* exceeds in Point of Neatneſs and Elegance all that has been yet made, if you except the Motions of the Satellites of *Jupiter* and *Saturn*; but there ſeems a great Deal wanting yet, to render an Orrery more ſimple in its Structure, and of an eaſier Purchaſe than thoſe which have been hitherto made; for the firſt were ſold for a thouſand Guineas; and I have heard of none of the largeſt Sort for leſs than three hundred Guineas.

Euphroſ. Had the ancient Aſtronomers no Contrivance of this Kind, to repreſent the Motions of the heavenly Bodies?

Cleon. Yes, it appears they had ſomething analogous to it, made by that famous Mathematician, *Archimedes*, on whom the *Latin* Poet *Claudian*, wrote a merry Epigram, in the *Engliſh* Tranſlation of which you will ſee *Rowley*'s Name, inſtead of *Archimedes*, as given us by Dr. *Harris* in his aſtronomica Dialogue, Page 182.

When lately Jove *the Orrery ſurvey'd,*
He, ſmiling, thus to Gods in Council ſaid;

How ſhall we ſtint preſuming Mortals Pow'r?
The Syracuſian *Sage did, once before,*
The heav'nly Motions ſhew in Spheres of Glaſs,
And the erratic Orbs and Stars expreſs:
But his Machine, by one fix'd Pow'r and Weight,
Mov'd, and was govern'd, as we are, by Fate;
While the bold Rowley, *in his Orrery,*
Keeps his firſt Pow'r, juſt like his Genius, free:
He knows the ſecret Spring, and can impart
Laws to the Whole, and to each ſingle Part.
His daring Hand, or brings, or hinders Fate:
He makes the Earth thro' ſilver Zodiacs run,
Juſtly obſequious to the golden Sun:
While the bright Moon, ſhining with borrow'd Light,
Marks out the Months, and rules the ſable Night:
And all obedient to his ſole Command,
Turn round their Axis, as he turns his Hand;
Their Phaſes, and their Aſpects all diſplay,
And at his Beck exhibit Night or Day.
He makes Eclipſes, as he will, appear,
For any paſt, preſent, or future Year;
Shews their true Courſe, and roots out vulgar Fear.
Guiltleſs Salmoneus *at your Suit I ſlew,*
Shall I, to pleaſe you, take off Rowley *too?*
Oh! no, all cry'd, the glorious Artiſt ſpare,
Tranſplant him hither, and make him a Star.

Euphroſ. This is an ingenious Piece of Wit, indeed; but the Inſtrument highly deſerves it, to all Appearance; it being in the external Frame, and (I doubt not) in the internal Structure, an admirably beautiful and exquiſite Piece of Workmanſhip.

Cleon. All you obſerve is very right; and Pity it is, that the Coſtlineſs and Magnificence of ſo curious and uſeful an Inſtrument ſhould be a Bar to its common Uſe. I ſhall now proceed to give you a View of each particular Part, in a general Deſcription of the Whole.

The Frame, which contains the Wheel-work, *&c.* and regulates the whole Machine, is made of fine Ebony, and is near four Feet in Diameter ; the Outſide thereof is adorned with 12 Pilaſters, curiouſly wrought and gilt: Between theſe Pilaſters the twelve Signs of the Zodiac are neatly painted, with gilded Frames. Above the Frame is a broad Ring, ſupported with twelve Pillars ; this Ring repreſents the Plane of the Ecliptic, upon which there are two Scales of Degrees, and between theſe the Names and Characters of the twelve Signs. Near the Outſide is a Scale of Months and Days, exactly correſponding to the Sun's Place at Noon, each Day throughout the Year.

Above the Ecliptic ſtand ſome of the principal Circles of the Sphere, according to their reſpective Situations in the Heavens, *viz.* (No. 10.) are the two Colures, divided into Degrees and half Degrees. No. 11. is one Half the Equinoctial Circle, making an Angle of 23½ Degrees. The Tropic of *Cancer* and the Arctic Circle are each fixed parallel, and at their proper Diſtance from the Equinoctial. On the Northern Half of the Ecliptic, is a Braſs Semi-circle, moveable upon two Points fixed in ♈ and ♎: This Semi-circle ſerves as a moveable Horizon, to be put to any Degree of Latitude upon the North Part of the Meridian. The whole Machine is alſo ſo contrived, as to be ſet to any Latitude, without in the leaſt affecting any of the Inſide Motions: For this Purpoſe, there are two ſtrong Hinges (No. 13.) fixed to the Bottom-Frame, upon which the Inſtrument moves ; and a ſtrong Braſs Arch, having Holes at every Degree, through which a ſtrong Pin is to be put, according to the Elevation. This Arch and the two Hinges ſupport the whole Machine, when it is lifted up, according to any Latitude ; and the Arch, at other Times, lies conveniently under the Bottom-Frame.

When the Machine is ſet to any Latitude, (which is eaſily done by two Men, each taking hold of two Handles, conveniently fixed for that Purpoſe) ſet the moveable Horizon to the ſame Degree upon the Meridian, and you may form an Idea of the reſpective Altitude, or Depreſſion of the Planets, both Primary and Secondary. The Sun (No. 1.) ſtands in the Middle of the whole Syſtem upon a Wire, making an Angle with the Plane of the Ecliptic of about 82 Degrees, which is the Inclination of the Sun's Axis, to the Axis of the Ecliptic. Next the Sun is a ſmall Ball (No. 2.) repreſenting *Mercury:* Next to *Mercury* is *Venus*, (No. 3.) repreſented by a large Ball, and both theſe ſtand upon Wires, ſo that the Balls themſelves may be more viſibly perceived by the Eye. The Earth is repreſented (No. 4.) by an Ivory-Ball, all having ſome of the principal Meridians and Parallels, and a little Sketch of a Map deſcribed upon it. The Wire, which ſupports the Earth, makes an Angle with the Plane of the Ecliptic of 66½ Degrees, which is the Inclination of the Earth's Axis to that of the Ecliptic. Near the Bottom of the Earth's Axis is a Dial-plate, (No. 9.) having an Index pointing to the Hours of the Day as the Earth turns round its Axis.

Round the Earth is a Ring, ſupported by two ſmall Pillars; which Ring repreſents the Orbit of the Moon, and the Diviſions upon it anſwer to the Moon's Latitude: The Motion of this Ring repreſents the Motion of the Moon's Orbit, according to that of the Nodes. Within this Ring is the Moon, (No. 5.) having a black Cap, or Caſe, which by its Motion repreſents the Phaſes of the Moon, according to her Age.—Without the Orbits of the Earth and Moon is *Mars* (No. 6.) The next in Order to *Mars* is *Jupiter*, and his four Moons (No. 7.) Each of theſe Moons is ſupported by a crooked Wire, fixed in a Socket, which turns about the Pillar that ſupports *Jupiter:* Theſe *Satellites* may be turned by the Hand to any Poſition; and yet, when the Machine is put into Motion, they will all move in their proper Times. The outermoſt of all is *Saturn*, and his five Moons, (No. 8.) Theſe Moons are ſupported and contrived after the ſame Manner with thoſe of *Jupiter.* The whole Machine is put into Motion by turning a ſmall Winch, like the Key of a Clock, (No. 14.) and all the Inſide Work is ſo truly wrought, that it requires but very ſmall Strength to put the whole in Motion.

Euphroſ. How are theſe planetary Bodies to be put in Motion? Could I ſee, or be made ſenſible of it?

Cleon. Yes: Above the Handle there is a cylindrical Pin, which may be drawn a little out, or puſhed in at Pleaſure:

When it is puſh'd in, all the Planets, both Primary and Secondary, will move according to their reſpective Periods, by turning the Handle: When it is drawn out, the Motion of the *Satellites Jupiter* and *Saturn* will be ſtop'd, while all the reſt move without Interruption. This is a very good Contrivance to preſerve the Inſtrument from being clogg'd by the ſwift Motions of the Wheels belonging to the *Satellites* of *Jupiter* and *Saturn*, when the Motion of the reſt of the Planets are only conſidered.

There is alſo a Braſs Lamp, having two Convex Glaſſes, to be put in the Room of the Sun; and alſo a ſmaller Earth and Moon, made ſomewhat in Proportion to their Diſtance from each other, which may be put on at Pleaſure.

The Lamp turns round at the ſame Time with the Earth, and by Means of the Glaſſes caſts a ſtrong Light upon her: And when the ſmaller Earth and Moon are placed on, it will be eaſy to ſhew when either of them will be eclipſed.

Euphroſ. Well! I think every Thing admirably adapted to anſwer the Purpoſe of ſuch a Machine, and now I preſume you are ready to put it in Motion, and gratify my Sight with a View of the Secondary Planets as well as the Primary, in the various Revolutions, which I have not yet ſeen in any Inſtrument.

Cleon. I ſhall do it this Inſtant:——You ſee I put on the Handle, and puſh in the Pin juſt above it; and place a black Patch (or Bit of Wafer) upon the Middle of the Sun, right againſt the firſt Degree of *Aries* (♈). You may alſo place Patches upon *Venus*, *Mars*, and *Jupiter*, right againſt ſome noted Point in the Ecliptic. If you lay a Thread from the Sun to the firſt Degree of *Aries* (♈), you may ſet a Mark where it interſects the Orbit of each Planet; and that will be a Help to note the Times of their Revolutions.

Euphroſ. Why am I to place Patches upon *Venus*, *Mars* and *Jupiter*, and not upon *Mercury* and *Saturn*?

Cleon. Becauſe theſe Planets are known to have a Motion about their Axis by a conſtant Obſervation of the Motion of Spots, ſeen on their Surfaces, when obſerved through good Teleſcopes. Theſe Spots, like thoſe of the Sun, are found to be regular, and to deſcribe ſuch Lines on the Surfaces of the Planets as they really would do, were the Planets to be moved about their Axis, with thoſe Spots on their Surfaces in the Times and

Manner you here ſee repreſented in the Orrery, ſo that they plainly prove the diurnal Rotation of thoſe Planets. But as for *Mercury* and *Saturn*, the Spots have been obſerved on their Surfaces ſufficient to anſwer ſuch a Purpoſe.

Euphroſ. In what Times do thoſe Planets revolve about their Axis?

Cleon. You will immediately ſee; for obſerve, one entire Turn of the Handle anſwers to the diurnal Motion of the Earth round her Axis, as may be ſeen by the Motion of the Hour-Index, which is placed at the Foot of the Wire, on which the *Terella* is fixed. When the Index has moved the Space of Ten Hours, you may obſerve, that *Jupiter* has made one Revolution compleat round its Axis: The Handle, being turned until the Hour-Index has paſſed over 23 Hours, will bring the Patch upon *Venus* to its former Situation with reſpect to the Ecliptic, which ſhews that *Venus* (♀) has made one entire Revolution round her Axis. *Mars* makes one compleat Revolution round his Axis in 24 Hours, and about 40 Minutes. When the Handle is turned 25 ½ Times round, the Spot upon the Sun will point to the ſame Degree of the Ecliptic, as it did when the Inſtrument was firſt put in Motion. And, thus by obſerving the Motion of the Spots upon the Surface of the Sun, and of the Planets in the Heavens, their diurnal Motion was diſcovered; after the ſame Manner as we do here obſerve the Motion of their Repreſentatives, by that of the Marks placed upon them.

Euphroſ. Theſe Things delight me very much, as they are quite new to me; I obſerve alſo, that the Earth moves upon its Axis; but as this is a more important Subject, it will require a particular Conſideration, which I ſhall trouble you with ſome other Time; at preſent I ſhall be glad to attend you on the Subject of the inferior Planets, and their Motion round the Primary; and firſt, if you pleaſe, let me obſerve the Motion of the Moon about the Earth at the ſame Time as the Earth keeps moving on in her Orbit about the Sun.

Cleon. This you ſhall do, and perform it with your own Hands: Take the Winch, and while you turn the Handle you will obſerve the Planets perform their Motions, in the ſame relative Times as they really do in the Heavens; then about the Earth you will obſerve, that the Lunar Orb will depart from a

Point in the Ecliptic about the Earth, and return to the ſame again in 27 Turns and $\frac{1}{4}$ of the Handle, which is called the periodical Month; in Contradiſtinction to the ſynodical Month.

Euphroſ. Pray, what is the Difference then between the *periodical and ſynodical Month?* You have formerly mentioned it to me by Way of Theory, and I ſhould be glad to ſee it exemplified, as it were, in Fact.

Cleon. I will ſhew you wherein the Difference conſiſts: I have already obſerved to you, that the periodical Month is the Time, which is taken up by the Moon in departing from any one Point of the Ecliptic, and returning to it the ſame again; but more particularly thus: I ſtop the Motion of the Earth, and place the Moon juſt between the Earth and the Sun; which you know is what we then call the *New Moon*; then, putting the Machine in Motion, you obſerve, that in 27 and $\frac{1}{4}$ Turns of the Handle, the Moon will make one Revolution, and come to the ſame Point between the Earth and the Sun again; therefore were the Earth to ſtand ſtill in the Heavens, the Space of Time between the new Moons would then be 27 and $\frac{1}{4}$ Days, and the periodical Months would then be the ſame. But, as the Caſe now ſtands, ſince the Earth really has a Motion about the Sun, at the ſame Time that the Moon moves about it, we muſt repreſent both in Motion in the Orrery: Therefore, bringing the Moon in the Situation between the Earth and the Sun as before, you will obſerve, by turning the Winch, that while the Earth moves progreſſively on, you will make not leſs than 29 $\frac{1}{2}$ Turns of the Winch, before the Moon will come exactly between the Earth and the Sun again; and this ſhews the Space of Time in what we uſually call the *ſynodical Month*, *viz.* two Days and $\frac{1}{4}$ longer than the *periodical Month.*

Euphroſ. You have made the Thing very clear and eaſy to be underſtood; and I fancy I ſhall be able to read a Lecture on the Orrery myſelf e'er long: The Moon, you ſee, always ſhews the ſame Face to the Earth in the Orrery as it does in the Heavens; how comes that to paſs, *Cleonicus?*

Cleon. For this Reaſon, that juſt ſo much of her Surface as is turned towards the Earth, by her monthly Motion, is turned from it by her Motion round her Axis, which is performed juſt in the ſame Time; for, if ſhe had no Motion about her Axis, all

Parts of the Moon's Surface would be ſhewn towards the Earth ſucceſſively in the Courſe of one Revolution; but of this I ſhall give you a farther Illuſtration another Time.

Euphroſ. I muſt not expect to know every Thing at once. I ſhall always be content to wait the Time, you think moſt proper for my Inſtruction. ——— But now for the *Moons* of *Jupiter*; let me ſee how they perform their Periods round their Primary.

Cleon. This you will do immediately; but let us place all the *Moons* of *Jupiter* in one right Line, from their reſpective Primaries, and then you will obſerve, by turning the Handle, that they are ſoon ſeparated and diſperſed one from the other, according to their different Celerities: Thus, you ſee, one Turn of the Handle brings the firſt Moon about $\frac{4}{7}$ Parts round *Jupiter*, while the Second has deſcribed but $\frac{2}{7}$ Parts; the Third about $\frac{1}{7}$, and the Fourth not quite $\frac{1}{16}$ Part, each of its reſpective Orbits.

Euphroſ. Yes; and by the Hour-Index I further obſerve, that the firſt *Moon* will in 18 and $\frac{1}{8}$ Hours come round to its former Poſition, or make one Revolution. The Second at the ſame Time will be almoſt oppoſite to the Firſt, and ſo has made but little more than half a Revolution in the ſame Time, and the others are in different Aſpects according to the Length of their Periods. In ſhort, I have the Pleaſure now to ſee, by telling the Turns of the Handle, and obſerving the Hour-Index, that the ſeveral Planets of *Jupiter* perform their Periods in the ſame Times that you formerly mentioned. But theſe *Moons* of *Jupiter* have been rendered very famous on Account of finding the Longitude by them; now I ſhould be glad to underſtand the Reaſon of that Affair. Pray, *Cleonicus*, could I be aſſiſted in that Reſpect by this Piece of Machinery?

Cleon. Yes, my *Euphroſyne*, you may very eaſily; by Means of the Eclipſes, which theſe *Moons* ſuffer in the Shadow of *Jupiter*; and to make the Thing as clear to you as poſſible, I ſhall place the Lamp in the Room of the Sun in the Centre to caſt a Light on the Body of *Jupiter* and his little Syſtem of *Moons*; by this Means, the Shadow of *Jupiter* and his Moons will be very evident on a Piece of white Paiſt-board placed directly behind them from the Sun. And now, by carrying the Candles out of the

Room, *Jupiter* will have no other Lights but what it receives from the Lamp.

Euphroſ. This is a Sort of Repreſentation of the gloomy Regions thro' which *Jupiter* with his Attendants move; and I plainly perceive, the Shadow of *Jupiter* and of his *Moons* too on the Paiſtboard; I plainly ſee the Manner of their apparent Motions; that they move backward and forward in one ſtraight Line, or nearly ſo: But here they appear very different from what they formerly did thro' the Teleſcope, where they appeared as ſo many brilliant Points; here only as dark moving Shadows; and I eaſily apprehend, by what I ſee, that when one of thoſe little *Moons* gets into the Shadow of *Jupiter*, it muſt neceſſarily diſappear to us on that yonder Ball of Earth; and then is ſaid to be eclipſed.

Cleon. This is very true, with reſpect to their Appearance on the Paiſtboard; but as for the *Moons* themſelves, you have a much better Idea of their Motions now than you could poſſibly have thro' the Teleſcope; for here, you ſee, they move in their proper circular Orbits, as they really do in the Heavens; and here alſo, you obſerve, the little white Balls go into, and out of *Jupiter*'s Shadow in the ſame Manner as they do there.

Euphroſ. This I view with Pleaſure, and theſe Eclipſes of the little *Moons*, I obſerve, are very frequent in thoſe which are next to their Primary, and perform their Periods in the ſhorteſt Time. And therefore, I preſume, the firſt of theſe *Moons* muſt afford the beſt Opportunity of finding the Longitude, by Reaſon of the Frequency of its Eclipſes.

Cleon. What you ſay is very juſt, there being, generally, two of thoſe Eclipſes in three Days; and therefore they afford Mariners and Geographers Opportunities of finding the Longitude almoſt as often, and as exactly, as they pleaſe.

Euphroſ. But what Method do they take for this Purpoſe, *Cleonicus?*

Cleon. I will inform you as intelligibly as I can; and in order thereto you muſt obſerve the following Particulars.

Firſt, That by reaſon the Theory of *Jupiter*'s Moons is very well aſcertained by Obſervations, the Times in which any of the Eclipſes of *Jupiter*'s Moons happen can eaſily be aſſigned by Aſtronomers; and accordingly, the Time of the Immerſions and Emerſions of the firſt *Satellite* are calculated in *White*'s *Ephemeris*, to anſwer this valuable Purpoſe. *Secondly*, That the Earth moving about its Axis once in 24 Hours, it is plain, that in one Hour a 24th Part of the Equator will paſs under the Meridian of any Place; that is to ſay, 15 Degrees of Motion under the Equator anſwers to one Hour of Time, which is 1 Degree in 4 Minutes, or 15 Minutes of a Degree in one Minute of Time. *Thirdly*, The Eclipſes of theſe *Satellites* are ſeen at the ſame Inſtant in every Part of the Earth where the Planet is viſible; therefore, *Fourthly*, If two Perſons, under the ſame Meridian, obſerve ſuch an Eclipſe, it muſt neceſſarily appear to them at the ſame Time by a Clock or Watch; but if they live under different Meridians, the Time ſhewn by their Clocks will be different, when they obſerve this Phænomenon; and this Difference of Time turned into Motion, by allowing, as I mentioned above, 1 Degree to 4 Minutes, will ſhew the Difference of the two Meridians in Degrees of the Equator; and this is all that they call *finding the Longitude*.

Euphroſ. I doubt not but I ſhall more eaſily underſtand theſe Things, when I have thought about them a little longer; but as I have always found theſe Ideas much facilitated by Example, I ſhould be glad if you would oblige me in that Reſpect with an Inſtance how Longitude is found between any two particular Places; as at *London*, and any other Place.

Cleon. I will, my *Euphroſyne*; ſee, here is *White*'s *Ephemeris* for the preſent Year 1757, where all the Immerſions of the firſt *Satellite* are particularly regiſtered from the Beginning of *January* to the 3d of *May*, and after that, the Emerſions out of *Jupiter*'s Shadow to *December*, for the ſeveral Days, Hours, Minutes, and Seconds, when they happen, as you here obſerve in their reſpective Columns.

Euphroſ. I ſee them all; and take Notice, that at the End of the Table, he ſubjoins an Example of its Uſe, which is the very Thing I want to ſee explained.

Cleon. That you ſhall inſtantly; as thus; ſuppoſe you was in ſome particular Place on the 9th Day of next *October*, and there, with a good reflecting Teleſcope, you obſerved the firſt *Satellite* of *Jupiter* emerging out of the Shadow at 44 Minutes, and 22 Seconds paſt 10 o'Clock at Night, by a good Watch, that ſhews Seconds; then you would take the *Ephemeris*, and ſee what Time the ſame Phænomenon happened at the Royal Obſervatory at *Greenwich*, (to which the Numbers in the Table are adapted;) and you will find againſt *October* the 9th, that it was 48 Minutes, and 42 Seconds after 8 at Night. Now the Difference between the Times of Obſervation at *Greenwich*, and the Place you are ſuppoſed to be in, is 1 Hour, 55 Minutes, and 40 Seconds, which, converted into Degrees and Minutes, in the Equator, will make 28 Degrees, and 5 Minutes, allowing for every Minute of Time 15 Minutes of a Degree as before mentioned.

Euphroſ. So that theſe 28 Degrees and 5 Minutes are what you call the Difference of Longitude of thoſe two Places; but Mr. *White* ſays, this is the Longitude of the Place of Obſervation to the Eaſt of the *Britiſh* Obſervatory: But why does he ſay *to the Eaſt*, *Cleonicus?* This I do not clearly underſtand.

Cleon. This you will eaſily apprehend, my *Euphroſyne*, if you conſider, that the Diurnal Motion of the Earth is *Eaſtward*, and therefore, at whatever Moment of Time the Eclipſe is ſeen at a Place 15 Degrees Eaſtward, it muſt neceſſarily be one Hour later than the ſame appears at the Obſervatory at *Greenwich*; and if the Place were Weſtward 15 Degrees, then it would happen 1 Hour ſooner than at the Obſervatory; but of this Affair you will be more particularly convinced when we come to the Uſe of the Globes.

A Table of the Eclipſes of *Jupiter*'s firſt Satellite, reduced to apparent Time, 1757.

Immerſions

JANUARY

d.	h.	m.	ſ.
2	15	13	41
4	9	41	11
6	4	8	43
7	22	36	16
9	17	3	49
11	11	31	19
13	5	58	49
15	0	26	30
16	18	54	12
18	13	21	56
20	7	49	41
22	2	17	28
23	20	45	15
25	15	13	9
27	9	41	4
29	4	9	7
30	22	37	11

FEBRUARY

Immerſions

d.	h.	m.	ſ.
1	17	5	14
3	11	33	18
5	6	1	27
7	0	29	37
8	18	57	51
10	13	26	6
12	7	54	23
14	2	22	41
15	20	51	3
17	15	19	26
19	9	47	59
21	4	16	33
22	22	45	6
24	17	13	40
26	11	42	16
28	6	10	53

MARCH

Immerſions

d.	h.	m.	ſ.
2	0	39	31
3	19	8	10
5	13	36	53
7	8	5	37
9	2	34	27
10	21	3	17
12	15	32	7
14	10	0	57
16	4	29	48
17	22	58	39
19	17	27	28
21	11	56	18
23	6	25	11
25	0	54	4
26	19	22	58
28	13	51	53
30	8	20	54

APRIL

Immerſions

d.	h.	m.	ſ.
1	2	49	55
2	21	18	47
4	15	47	39
6	10	16	31
8	4	45	24
9	23	14	18
11	17	43	12
13	12	12	4
15	6	40	56
17	1	9	53
18	19	38	50
20	14	7	39
22	8	36	28
24	3	5	14
25	21	34	1
27	16	2	47
29	10	31	33

MAY

Immerſions

d.	h.	m.	ſ.
1	5	0	16
2	23	28	59

Emerſions

d.	h.	m.	ſ.
4	20	5	50
6	14	34	28
8	9	3	6
10	3	31	42
11	22	0	19
13	16	28	51
15	10	57	23
17	5	26	0
18	23	54	37
20	18	23	4
22	12	51	32
24	7	19	57
26	1	48	22
27	20	16	45
29	14	45	8
31	9	13	29

JUNE

Emerſions

d.	h.	m.	ſ.
2	3	41	51
3	22	10	18
5	16	38	46
7	11	7	4
9	5	35	23
11	0	3	40
12	18	31	57
14	13	0	15
16	7	28	33
18	1	56	50
19	20	25	8
21	14	53	27
23	9	21	46
25	3	50	9
26	22	18	33
28	16	46	53
30	11	15	13

JULY

Emerſions

d.	h.	m.	ſ.
2	5	43	35
4	0	11	57
5	18	40	21
7	13	8	46
9	7	37	13
11	2	5	41
12	20	34	17
14	15	2	53
16	9	31	26
18	4	0	0
19	22	28	37
21	16	57	14
23	11	25	56
25	5	54	38
27	0	23	22
28	18	52	7
30	13	20	55

AUGUST

Emerſions

d.	h.	m.	ſ.
1	7	49	44
3	2	18	41
4	20	47	38
6	15	16	36

A Table of the Eclipſes of *Jupiter*'s firſt Satellite, reduced to apparent Time, 1757.

Emerſions				Emerſions				Emerſions				Immerſions			
AUGUST				SEPTEMBER				OCTOBER				DECEMBER			
d.	h.	m.	ſ.	d.	h.	m.	ſ.	d.	h.	m.	ſ.	d.	h.	m.	ſ.
8	9	45	34	7	12	1	42	5	19	50	26	11	23	41	3
10	4	14	35	9	6	31	1	7	14	19	36	13	18	8	39
11	22	43	37	11	1	0	24	9	8	48	42	15	12	36	15
13	17	12	42	1	19	29	48	11	3	17	48	17	7	3	47
15	11	41	47	14	13	59	8	12	21	46	51	19	1	31	18
17	6	10	51	16	8	28	28	14	16	15	53	20	19	58	51
19	0	39	56	18	2	57	46	16	10	44	51	22	14	26	23
20	19	9	12	19	21	27	4	18	5	13	49	24	8	53	58
22	13	38	28	21	15	56	20	19	23	42	48	26	3	21	33
24	8	7	38	23	10	25	37	21	18	11	46	27	21	49	5
26	2	36	48	25	4	54	54	23	12	40	37	29	16	16	36
27	21	6	3	26	23	24	11	25	7	9	27	31	10	44	5
29	15	35	18	28	17	53	30	27	1	38	11				
31	10	4	34	30	12	22	49	28	20	6	55				
SEPTEMBER								30	14	35	40				
Emerſions.				OCTOBER											
				Emerſions				Conjunction of the *Sun* and *Jupiter*, *November* 21ſt							
2	4	33	51												
3	23	3	7	2	6	52	3								
5	17	32	24	4	1	21	16								

The Times of the Eclipſes in this Table are adapted to the Meridian of the Royal Obſervatory near *London*, and afford an excellent Method of diſcovering the Longitude, or Difference of Meridians, between that and any other Place whatſoever, which I ſhall illuſtrate by an *Example*.

Suppoſe on the 9th Day of *October*, the Time of the Emerſion of *Jupiter*'s firſt Satellite, be obſerved by a Teleſcope at 44 Min. 22 Sec. paſt 10 at Night; I find by the Table, that the Time of this Emerſion will happen at the *Britiſh* Obſervatory, the ſame Night, 48 Min. 42 Sec. paſt 8: The Difference of the Times is 1 Hour, 55 Min. 40 Sec. which converted into Deg. and Min. of the Equator, will make 28 Deg. 55 Min. the Longitude of the Place of Obſervation, to the *Eaſt* of the *Britiſh* Obſervatory.

Euphroſ. Well, I ſuppoſe by this Time you are tired of talking ſo much about the Longitude to one of our Sex, who are ſo ſeldom employed in putting in Practice any of the great Diſcoveries of the Philoſophers; but as we have naturally a Curioſity of Enquiry into every Thing that we hear of that is of a public or wonderful Nature, we are oftentimes ſolicitous to be ſatisfied about Things that do not ſo immediately concern us. Of this I ſhall give you a farther Inſtance by a Query or two concerning *Saturn*, his *Moons*, and *Ring*. I ſee they move, after the ſame Manner with thoſe of *Jupiter*, about their Primary; but I obſerve this Syſtem of *Moons* has not the ſame Poſition with reſpect to the Plane of the *Orrery* as thoſe of *Jupiter* have; but as the Time is now far advanced, I ſhall beg a more particular Account of what relates to *Saturn* and his Syſtem the next Opportunity we have for Converſe on theſe Subjects.

DIALOGUE VIII.

The Uſe of the Orrery *continued.*

Cleonicus.

I Remember you took Notice, that *Saturn*'s *Moons* were not alike poſited with thoſe of *Jupiter*, in regard to the Ecliptic. And it is true, they are not; for thoſe of *Jupiter* are parallel to that; but thoſe of *Saturn* are inclined thereto in an Angle of about 30 Degrees; as is alſo the Plane of his Ring.

Euphroſ. Then, I perceive, that the Shadow of *Saturn*'s *Moons*, caſt on the Paiſtboard behind them, will not appear to move backward and forward in a right Line, like thoſe of *Jupiter*.

Cleon. You rightly obſerve, they cannot appear ſo to move to an Eye placed upon the Earth; as you will eaſily ſee by the Experiment; for having placed the Paiſtboard properly behind this Planet, and taken all the Candles but one out of the Room —— lay your Hand on the Winch, and put them in Motion, and then you ſee on the Paiſtboard, that each reſpective *Satellite* deſcribes an Orbit of an oval Figure, and what the Geometers properly call an *Elipſis*, one Part of which lies above, and the other below the *Planet*, and its *Ring* in the Center.

Euphroſ. It greatly delights me to obſerve theſe curious Appearances; and now I ſee, in Fact, how Things are in Nature performed, and brought about: I ſee the Reaſon why the *Moons*, while they deſcribe the remote Part of their Orbit, appear direct in Motion, and retrograde, while they deſcribe that Part next to us: —— I ſee likewiſe, that the Shadow of the *Ring*, in like Manner, is not circular, but eliptical, including the Body of *Saturn*, very much like what formerly appeared in the Heavens thro' the Teleſcope.

Cleon. It muſt undoubtedly be pleaſant to ſee the wonderful Machinery of Nature thus repreſented in Epitome, and yet, at the ſame Time, ſo perfectly; but there is one Thing which you have not yet adverted, and that is, that *Saturn* and his whole Syſtem, and the Motion about the *Sun*, obſerve a Paraliſm of Poſition; or in other Words, the *Planet*, his *Ring*, and *Satellites*, always reſpect the ſame Part of the Heavens in every Part of their Orbits; and this you will eaſily perceive, if you attend to it but a very ſhort Time; but as this is a curious Phænomenon, I ſhall repreſent it to you in the *Orrery*, by Means of the *Lamp* in the Place of the *Sun*, and the *Paiſtboard*, connected with the Stem of the *Planet*; ſo as always to be behind it, by which Means the Shadow of the *Ring* will caſt a Shadow upon the Paiſtboard, and thereby the ſeveral Phaſes of the *Ring* will plainly appear, as they are obſerved thro' a Teleſcope in the Heavens during the ſeveral Parts of his long Revolution.

Euphroſ. This would be a delightful Spectacle, indeed; but, I fear, it will coſt you a good deal of Time and Trouble; ſince the Motion of this *Planet* is ſo very ſlow, even in the *Orrery* itſelf.

Cleon. I ſhall think no Time or Trouble too much, or ill-ſpent, to inform the Mind of my dear *Euphroſyne.* Beſide that, we need only obſerve the Phaſes of the *Ring* thro' one fourth Part of its Period; and ſeven Years, you know, will ſoon be over in the *Orrery*; but it will be neceſſary, in the firſt Place, to bring this Planet to that Part of its Orbit where the Plane of its *Ring* is moſt of all open to the View of the

Spectator upon the Earth. This is about the 20th Degree of *Sagitarius*, which Place *Saturn* poſſeſſed at the latter End of the Year 1752, to which Place, you ſee, I now bring the Planet; and the Shadow of the *Ring* on the Paiſtboard is ſuch, as ſhews near the whole Body of the *Planet* within it.

Euphroſ. I ſee it does, and ſhould have been glad to have had an Opportunity, at that Time, of ſeeing ſo fine an Appearance of the *Ring* thro' a Teleſcope, and the large Space between it and the Body of *Saturn*. I think it is conſiderably different from what I obſerved it ſome Months ago.

Cleon. You will not wonder at that, when you conſider, that a few Years make a great Alteration in the Appearance of the eliptic Figure of the *Ring*. For as the *Planet* moves on, at the Rate of about 12 Degrees in a Year, and the *Ring* always keeps parallel to itſelf, it muſt be in a Situation, at this Time, much more oblique to the View. —— Keep turning the Winch, and you will ſee the Shadow of the *Ring* becomes more and more eliptical, 'till at length you obſerve the *Planet* is in the 11th Degree of *Aquarius*, where it is at this very Time, as ſeen from the Earth.

Euphroſ. Then here I will ſtop and view it; and, indeed, I ſee it much the ſame as I did through the Teleſcope, and by this Means am fully convinced how juſt a Repreſentation this is of Nature. But will not the Pleaſure of viewing this *Ring* decreaſe with its Dimenſions?

Cleon. Perhaps not; ſince Variety always is productive of Pleaſure, in ſome Degree. —— For now turn the Winch again, and you will obſerve, that, when the *Planet* arrives at about 10 Degrees of *Piſces*, the *Ring* ſeems little more than as a Line that lies over the *Planet*, and at a ſmall Diſtance on either Side; and thus it will appear in the Beginning of the Year 1759, ſoon after which, it entirely diſappears; and in the Beginning of the Year 1760, it arrives to the Place of the *Nodes* of the *Ring*, which is in about 20 Degrees of *Piſces*, then the *Plane*, paſſing thro' the Eye of the Spectator, projects the Shadow of the *Ring* into a ſtrait Line, juſt over the Middle of the Diſk of the *Planet*; and if you live to view the Planet at that Time, thro' a Teleſcope, you will ſee nothing at all of its *Ring*. From this Situation keep him moving on, and it will be nearly ſix Months in the *Orrery* before the *Ring* will appear any otherwiſe than a right Line. But you will obſerve, that ſoon after he enters the Sign of *Aries*, the Shadow of the *Ring* will again appear to be curved, which will be in the Year 1761, when the other, or ſouthern Side of the *Ring* will be enlightened by the *Sun*. Thus every ſucceſſive Year the Phaſes of the *Ring* will return again 'till ſeven Years are compleated, when the *Ring* will be again moſt open to the Teleſcopic View of the Spectator, which will be in the latter End of the Year 1767, where we may now leave that gloomy Planet; for we can ſee no more Variety in the remaining half of its Orbit than you have obſerved in this.

Euphroſ. I would not give you any unneceſſary Trouble, to inſiſt longer on this Phænomenon, as it muſt neceſſarily be a Repetition of the ſame Thing, which I can as eaſily conceive without ſeeing it, as with. I ſhall be extremely deſirous often to view this *Planet* with a Teleſcope; eſpecially, as the Time is now approaching, when the greateſt Variety of theſe Phaſes will entertain the Eye. But methinks it will be a long Time before I ſhall have the Pleaſure of viewing the *Ring* in its moſt ample Extent.

Cleon. Why that is the moſt curious of all the Phaſes of *Saturn*'s *Ring*, and it may poſſibly happen, that you may ſee a fixed Star in the Space between the *Planet* and its *Ring*; for this we are aſſured of by Mr. *Whiſton*, that Dr. *Clarke*'s Father once ſaw a Star in that Situation.†

Euphroſ. There would be no Reaſon for me to expect ſuch a Sight, as, I preſume, it muſt be a very rare Appearance, if only one Man has been obſerved to ſee it; but, pray, who was the firſt Diſcoverer of this wonderful Phænomenon of *Saturn*'s *Ring*, and how many Years is it ſince?

Cleon. We owe this happy Diſcovery to the Inventor of the Teleſcope itſelf, with which it was ſeen, the famous *Gallileo*, an *Italian* Mathematician and Philoſopher, who firſt of all viewed it, and publiſhed it to the World in the Year 1610, in an ænigmatic *Latin* Sentence, importing, that he had viewed *Saturn* with three Bodies; meaning the Body of *Saturn* itſelf

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† *Whiſton*'s Memoirs of Dr. *Clarke*'s Life.

ſelf in the Middle, and the oval *Anſæ*, or Ends of *Saturn*'s *Ring*, which appeared, at firſt Sight, like two other Globes,† tho' imperfectly; and, indeed, it was two whole Years before he was convinced that *Saturn* was not a triple Body. However, by frequently viewing of him, he obſerved, with many others, that it was nothing more than a large *Ring*, encompaſſing the Body.

Euphroſ. If this Gentleman was the Inventor of the Teleſcope, he probably was the firſt too, who muſt have had the great Pleaſure of viewing the *Moons* of this *Planet*.

Cleon. It is natural for you to imagine ſo; but this, however, was not the Caſe; for his Teleſcope, by which he ſaw the *Ring*, was not ſufficient to ſhew the *Moons*, as it magnified only about 30 Times; but one that will exhibit a View of all *Saturn's Satellites* muſt have a much greater magnifying Power. This happy Spectacle was reſerved to reward the Ingenuity of the celebrated *Hugenius*, who tells us, in his Treatiſe, called *The Celeſtial Worlds diſcovered*, that the 4th of *Saturn*'s *Moons* (which is the largeſt and brighteſt of all) he firſt diſcovered in the Year 1655, with a refracting Teleſcope, not above 12 Feet long; the other four were diſcovered by the induſtrious *Caſſini*, an *Italian* Philoſopher, who had the Opportunity of much longer Teleſcopes, *viz.* from 30 to 136 Feet long; the 3d and 5th he diſcovered in the Year 1671, and the two Innermoſt in the Year 1686; at Length, he could view all the Five with a 34 Foot Tube. He gave them the Title of *Sidera Ludoicea*, in Honour of *Louis le Grand*, in Imitation of *Gallileus*, who, ſome Years before, had diſcovered the four *Satellites* of *Jupiter*, and called them by the Name of *Medicea Sidera*, in Compliment to *Medicis* II. Great Duke of *Tuſcany*, to whom he addreſſed this Diſcovery, in the Year 1610; but enough of this at preſent; for I intend to put into your Hands very ſoon the before-mentioned Book of *Hugenius*, wherein you will be highly entertained with the moſt ingenious Conjectures concerning the Inhabitants, Plants, and Productions of the *Worlds* in the *Planets*. You have read *Fontinelle*'s Plurality of

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† He advertiſed this Diſcovery in this Sentence, *Altiſſimam Planetam tergenimum obſervavi*. In which all the Letters were tranſpoſed, as was the Cuſtom of thoſe Times in ſuch new Diſcoveries.

Worlds in *French*; but you will find this Treatiſe of *Hugenius* far ſuperior to that, and much better worth your Peruſal.

Euphroſ. That Book, or any other that you ſhall recommend, I ſhall be very ready to peruſe, as I know you can judge what is calculated for the Improvement of my Underſtanding. But what is that little Thing I ſee in your Hand?

Cleon. This is a ſmall Piece of Machinery, which I promiſed you ſome Time ago, by which I intend to give you a farther Illuſtration of that one remarkable Particular in the *Moon*, *viz. her ſhewing always the ſame Face to the Earth*, which we ſome Time ago touched upon, but abruptly left it, as there was no proper Machinery in the *Orrery* to repreſent it in ſo natural a Manner as was neceſſary to convince you of the true Reaſon of the Thing; nor muſt I allow you to aſk me any Queſtions concerning any particular Part of this Appurtenance, which I ſhall now place upon the *Orrery*. —— I take the common Earth and Moon away, and adding this in the room, you ſee the whole is become new.

Euphroſ. I obſerve it with great Pleaſure. ——— When I turn the Winch, I ſee no annual Motion of the Earth, only the diurnal Motion about its Axis. —— I ſee a little Ball hang by a String, which, I ſuppoſe, repreſents the *Moon*, with that Part of it next the Earth enlightened, and variegated with Spots, and brighter Parts, like what I ſee in the Face of the *full Moon* itſelf thro' the Teleſcope.

Cleon. That pendulous Ball does, indeed, repreſent the *full Moon*; for you ſee it is now in Oppoſition to the *Sun*; but what you are particularly to take Notice of is, that while the *Earth* moves upon its Axis, the *Moon* is moving about the *Earth*, in ſuch a Manner, as always to turn the ſame Part towards the *Earth*, as you ſee before the *Moon* did, which we removed from the Orbit; but here it is owing to a very different Cauſe from that in common *Orreries*, and *Planetariums*. This Effect is there produced by a well-known Piece of Machinery; but here it is owing to the ſame Cauſe, as in the Heavens, where you find neither Wheels nor Pullies to produce it.

Euphroſ. I am at a Loſs to gueſs what this inviſible Kind of Cauſe ſhould be. ——— I ſee, that the *Moon* turns conſtantly the ſame Face to the *Earth* in her monthly Courſe. ——

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I obſerve, at the ſame Time, that that viſible Part is more or leſs enlightened, and ſometimes wholly dark; but I can ſee nothing that produces this, unleſs it be the String by which it is ſuſpended. —— How this String ſhould cauſe it, I cannot conceive, as it is only hung on a braſs Stem by a Loop. —— I cannot ſay, but this looks moſt like Conjuration of any Thing I have ſeen yet. —— How am I to underſtand it, *Cleonicus?*

Cleon. Very eaſily, my *Euphroſyne.* There is nothing that will be difficult for you to underſtand, or that requires any magic Art to account for. Mechanics itſelf is only the Application of natural Powers to produce the Effects in Miniature, which we ſee in the World at large; nor does it follow, that, to anſwer this End, Wheels, Pullies, and other mechanical Contrivances, are always neceſſary. We may, ſometimes, ſubſtitute ſimilar Powers in Nature for producing the ſame Effects. Two Bodies will be actuated alike by the Powers of Gravity and Magnetiſm. If they are affected by theſe Powers only, they will always turn the ſame Parts towards each other. If one of them is fixed, and the other free to move, the latter will always turn the ſame Part to the former. And this is the Caſe before us. —— For the Earth is placed upon one End of an artificial Magnet, which was covered from your Sight, and in the pendent *Moon*, you will preſently ſee a Piece of a natural Load-ſtone is included, like a Kernel within a Shell, and the Power of Magnetiſm in theſe two Bodies, equally affecting both, cauſes, that the *Moon*, hanging in a free State, muſt always turn the ſame Part toward the central magnetic Body of the *Earth*, juſt as the *Moon* in the Heavens is made to do the ſame Thing, by the Power of Gravitation, towards the Globe of our Earth. —— You will by this Time underſtand it. —— See, here are both the Magnets.

Euphroſ. This delights me extremely, *Cleonicus*, and I perfectly comprehend you. —— This is down-right Nature, indeed, and ſufficiently convinces me how ſimple the Powers of Nature are, when compared with the complicated Contrivances of the moſt ingenious Mechanic. —— But what are the Conſequences, *Cleonicus*, that follow this curious Effect?

Cleon. The firſt is, that the *Moon* neceſſarily turns once round her Axis, in the ſame Time that ſhe moves once round the Earth; for by this Means, a Perſon on the *Moon*'s Surface, with his Eye directed conſtantly to the Earth, muſt unavoidably view every Point in the Circumference in the *Moon*'s Orbit, in the Time of one Revolution; but this he could not do, without being turned once round the Center of the *Moon*, at the ſame Time. —— Do you apprehend me, Siſter?

Euphroſ. I do very clearly; as I cannot but know, that to view every Point of a Circle, in which I am included, I muſt certainly turn myſelf once round. —— But there is another Thing, I obſerve, and that is, that thoſe People who are on the other Side of the *Moon* cannot poſſibly come at a Sight of the Earth at all.

Cleon. It is very true, they cannot, unleſs they will be at the Trouble of a Journey to that Hemiſphere next the Earth; and ſome of them, for this Purpoſe, muſt travel more than 1500 Miles. —— Another Thing you will as readily obſerve, that thoſe who inhabit the middle Part of the Surface of the *Moon*, next the Earth, will ſee the great Globe of the Earth conſtantly hanging over their Heads in the *Zenith*, while thoſe, who live in the moſt Eaſtern or Weſtern Parts of the ſaid Hemiſphere, will ſee one Half of our Globe in their weſtern and eaſtern *Horizon*.

Euphroſ. Well! this is all very ſtrange; but ſtill, I ſee, that it muſt be ſo. —— I ſhould be glad to have the Pleaſure of ſuch Views of the Earth myſelf; and were it poſſible, to get to the *Moon*, and if you could go with me, I ſhould almoſt be induced to ſet out.

Cleon. Conſider every Thing, my *Euphroſyne*, and you will not be in ſuch a Hurry to leave the Earth. You will find 240,000 Miles a tedious, aerial Journey, and you will find no Caſtles in the Air, nor Inns of Accommodation on the Road; and which is worſt of all, when you come there, it will be neceſſary for you to have the Art of flying inſtead of walking, as ſome of their Mountains are more than nine Miles perpendicular Height, and their Valleys 2 or 300 Miles deep, and as much over; ſo that, I fear, you would make but a poor Shift there. —— Beſides, another Thing you have not conſidered, and that is, that the Days and Nights there are a Fortnight long each, and ſuch tedious Intervals of Light and Darkneſs will not agree with your Conſtitution. You will, therefore, with more Pleaſure imagine all theſe Things, than go thither to enjoy them.

Euphroſ. Truly, you have cured my Curioſity ſufficiently, and I ſhall be content for the future to ſtay at my terreſtrial Home. However, I cannot help wiſhing, after all, that it may be ſome Part of our future Happineſs to viſit the diſtant Planets of the Syſtem, and even the planetary Worlds of other Syſtems beyond this. —— But enough of this at preſent; what will be the Subject of our next Speculation?

Cleon. As we are confined to the Globe of our Earth, we ſhall find many Subjects of Enquiry, and well ſuited to gratify a rational Mind, relative to the ſeveral Phænomena obſervable in it alone. And it is proper, that we ſhould underſtand them firſt, which will be ſufficient for the ſhort Space of Time allotted to human Life. Among theſe, the Seaſons of the Year are what I ſhall next explain to you on the *Orrery*.

DIALOGUE IX.

The Seaſons of the Year explained by the Orrery: *And Firſt the* SPRING.

Euphroſyne.

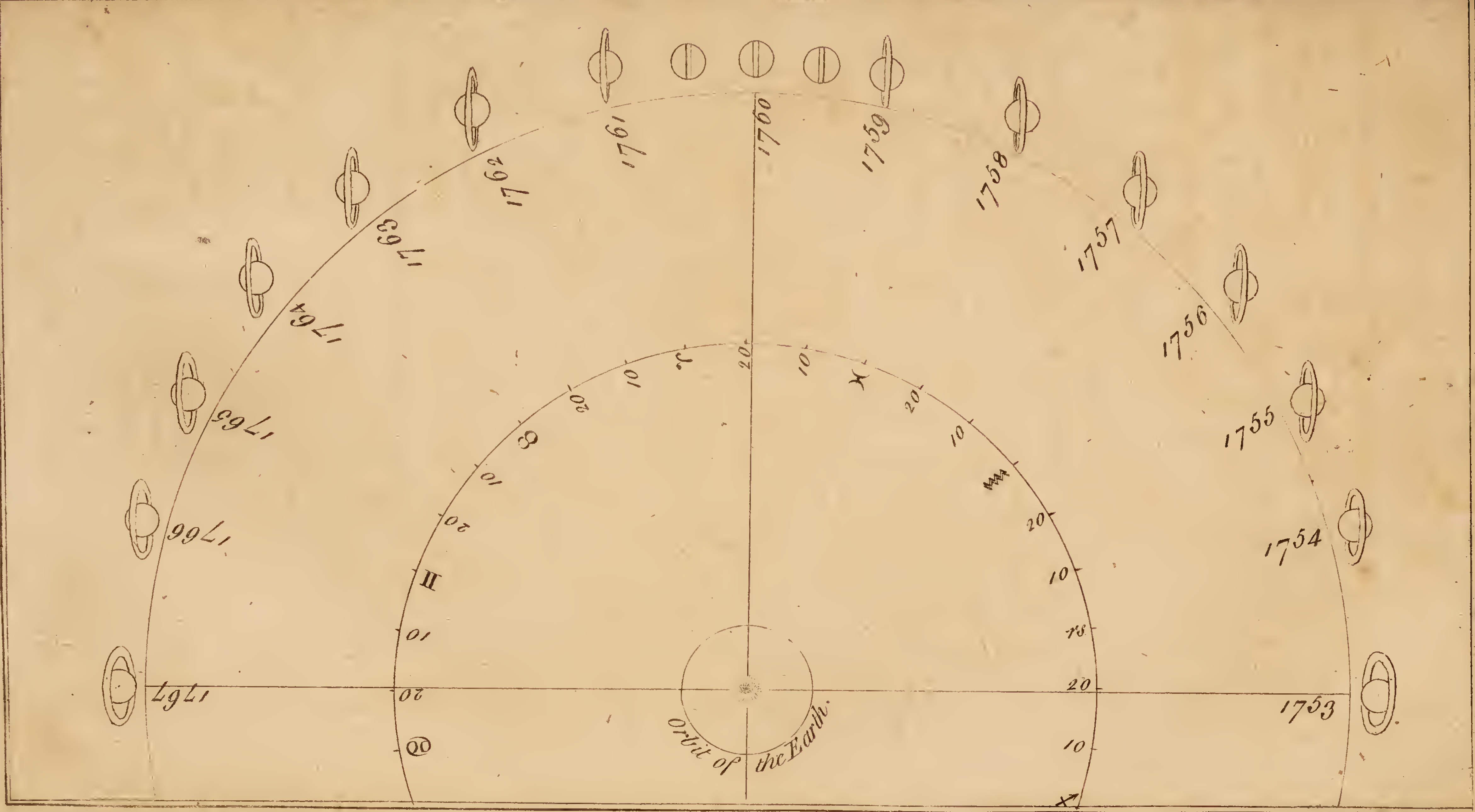
I Think, *Cleonicus*, when you left me Yeſter-night, you told me our next Buſineſs with the *Orrery* would be to explain the Nature of the SEASONS, and the Manner how they happen by it.

Cleon. I did ſo, my *Euphroſyne*; and I intend it for the Subject of your Entertainment this Afternoon, if you think fit, and are at Leiſure.

Euphroſ. Very much ſo; and am impatient of loſing one Moment of Time 'till I am made ſenſible in ſome Meaſure of the Reaſon and Cauſe of ſuch an agreeable Variety and Succeſſion of *Seaſons* which conſtitute the Year. For tho' no one is more ſenſible of Heat and Cold, or more affected with the Pleaſure and Beauties of the *Spring*, or the heavy and ill-

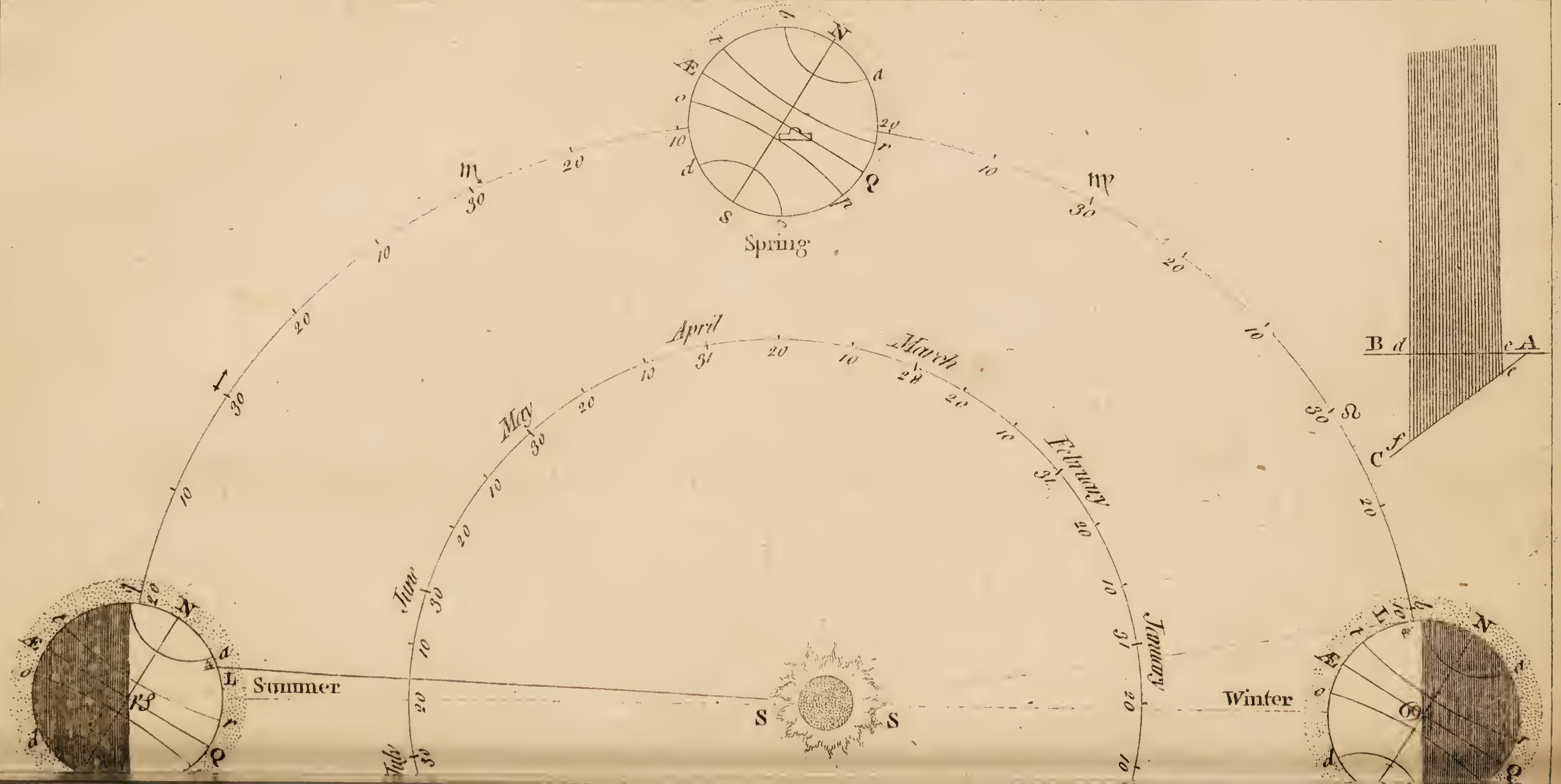
The PHASES of SATURNS RING

Plate XX.



The SEASONS of the YEAR.

Plate XXI.



boading Aſpect of *Autumn*; yet I have never been ſo rational as to enquire into the Cauſes thereof, as if I were no more concerned to know them than the Quadrupedes.

Cleon. This ingenuous Reflection on yourſelf, *Euphroſyne*, is but too juſt a Satire on the Generality of Mankind, to whom a moderate Purſuit of any Kind of Knowledge, in the Sciences, is thought but too irkſome. The Seaſons are the moſt obvious Parts of Nature, nor are they difficult to be underſtood by Means of the *Orrery*, as you will ſee. ——— *Ovid* has made a fine poetical Compariſon between the four Seaſons of the Year, and the four different States of a Man's Life in theſe Verſes.

Perceiv'ſt thou not the Proceſs of the Year:
How the four Seaſons in four Forms appear,
Reſembling human Life in every Shape they wear?
Spring firſt, like Infancy, ſhoots out her Head,
With milky Juice requiring to be fed;
Helpleſs, tho' freſh, and wanting to be led.
The green Stem grows in Stature and in Size,
But only feeds with Hope the Farmer's Eyes.
Then laughs the childiſh Year, with Flowrets crown'd,
And laviſhly perfumes the Fields around;
But no ſubſtantial Nouriſhment receives;
Infirm the Stalks, unſolid are the Leaves.
Proceeding onward, whence the Year began;
The Summer grows adult, and ripens into Man.
This Seaſon, as in Man, is moſt repleat
With kindly Moiſture and prolific Heat.
Autumn ſucceeds, a ſober, tepid Age,
Not froze with fear, nor boiling into Rage:
More than mature, and tending to Decay,
When our brown Locks repine to mix with odious Grey.
Laſt, Winter ſweeps along, with tardy Pace;
Sour is his Front, and furrow'd is his Face.
His Scalp, if not diſhonour'd quite of Hair,
The ragged Fleece is thin; and thin is worſe than bare.

DRYDEN'S OVID'S MET. L. XV.

Euphroſ. That is a very beautiful Deſcription of the Seaſons, and the Similitude ſeems very juſt and natural. ——— But now for a little Philoſophy; pray let me ſee, by the Orrery, how thoſe different Seaſons are brought about in Nature.

Cleon. I will, immediately; but, previous thereto, you muſt obſerve, and get a tolerable good Notion of the following Particulars ——— *Firſt*, That the Motion of the Earth is in the Plane of the *Ecliptic*; that therefore ——— *Secondly*, the Sun-beams are always perpendicular to that Part of the Earth which lies under the Degree of the *Ecliptic* in which the Sun appears at any Time. ——— *Thirdly*, That the Axis of the Earth is not perpendicular to the Plane of the *Ecliptic*, but inclined thereto in an Angle of 66° $\frac{1}{2}$; as I ſhewed you in the Sphere. ——— *Fourthly*, That the Axis of the Earth keeps always in a parallel Poſition, or points always towards the ſame Parts of the Heavens, throughout its whole annual Courſe. ——— *Fifthly*, That the Sun being at ſo vaſt a Diſtance, the Rays which fall on the Earth may be looked upon as parallel among themſelves: And, *Sixthly*, That only one Half of a Globe can be enlightened at once by parallel Rays. ——— Do you think you underſtand me a-right?

Euphroſ. I believe I do pretty well, by what you have before taught me; and the Manner in which you now indicate theſe Things.

Cleon. Well then, ſince the SPRING is the moſt delightful and primary Seaſon of the Year, we will begin with it; to repreſent which, you ſee, I place the Earth in the Beginning of *Libra* ♎, and then the Sun will appear in the Beginning of *Aries* ♈, which being the *Equinoctial Point*, the Sun muſt for that Day equally enlighten all Places on the Earth, from Pole to Pole; and to make this Affair as clear to the Eye, as it is in Nature, you ſee I take this ſmall, wax Taper, and —— ſhutting the Windows all cloſe ——— I put it into this little braſs Caſe, with a Convex Glaſs in the Side; that the Light may go to the Earth in parallel Rays ——— Then I fix it in the Place of the ſolar Ball, and —— turning the Glaſs directly to the Earth, ——— you ſee that Hemiſphere of the Earth next the Taper enlightened, ——— the other being wholly in the dark.

Euphroſ. I obſerve it well; and from what you ſhew'd me on the *Sphere*, I eaſily conceive, as the Earth revolves about its Axis, the Days, and Nights muſt now be of equal Duration. —— But, pray, when do you put the Earth in Motion, to obſerve the Particularities of Seaſons?

Cleon. Immediately; —— you ſee it begin its Courſe, proceeding for the Summer Seaſon; —— for ſince, now, every Part of the Earth, equally diſtant from the Equator, on either Side, enjoys equal Intervals of the Sun's Preſence and Abſence, the Warmth or Heat of every Clime muſt now be at a *Medium*, or in a moſt temperate Degree, and therefore will be productive of all the Vegetation of Plants, and pleaſant Temperature of Air, that any Part of the Earth is capable of; which Qualities, I need not tell you, do every where conſtitute the SPRING; which charming Seaſon has afforded a delightful Theme to the Poets, who have variouſly deſcribed it. Of which I ſhall repeat to you ſome choice Specimens. The Firſt ſhall be that of *Virgil.*

See on the Shore inhabits purple Spring,
Where Nightingales their Love-ſick Ditties ſing;
See Meads with purling Streams, with Flow'rs the Ground,
The Grottos cool with ſhady Poplars crown'd,
And creeping Vines on Arbours weav'd around.
Eclogue IX.

Again:

When Winter's Rage abates, when chearful Hours
Awake the Spring, and Spring awakes the Flow'rs;
'Tis then the Hills with pleaſing Shades are crown'd,
And Sleeps are ſweeter on the ſilken Ground;
With milder Beams the Sun ſecurely ſhines,
Fat are the Lambs, and luſcious are the Wines.

But his moſt beautiful, and grand Deſcription of this Seaſon is in the following Lines:

The SPRING *adorns the Woods, renews the Leaves,*
The Womb of Earth the genial Seed receives;

For then almighty Jove *deſcends and pours,*
Into his buxom Bride, his fruitful Show'rs;
And mixing his large Limbs with hers, he feeds
Her Births with timely Juice, and foſters teeming Seeds.
Then joyous Birds frequent the lonely Grove,
And Beaſts, by Nature ſtung, renew their Love.
Then Fields the Blades of bury'd Corn diſcloſe,
And while the balmy weſtern Spirit blows,
Earth to the Breath her Boſom dares expoſe.
With kindly Moiſture then the Plants abound,
The Graſs ſecurely ſprings above the Ground:
The tender Twig ſhoots upwards to the Skies,
And on the Faith of the new Sun relies.
The ſwerving Vines on the tall Elms prevail,
Unhurt, by ſouthern Show'rs, or northern Hail;
They ſpread their Gems, the genial Warmth to ſhare,
And boldly truſt their Buds in open Air.
In this ſoft Seaſon (let me dare to ſing)
The World was hatch'd by Heav'n's imperial King
In prime of all the Year, and Holidays of Spring.
Then did the new Creation firſt appear,
Nor other was the Tenor of the Year;
When laughing Heav'n did the great Birth attend,
And eaſtern Winds their wint'ry Breath ſuſpend.
Then Sheep firſt ſaw the Sun in open Fields,
And ſavage Beaſts were ſent to ſtock the Wilds;
And golden Stars flew up to light the Skies,
And Man's relentleſs Race from ſtony Quarries riſe.
Nor could the tender, new Creation bear
Th' exceſſive Heats, or Coldneſs of the Year;
But chill'd by Winter, or by Summer fir'd,
The middle Temper of the Spring requir'd:
When Warmth and Moiſture did at once abound,
And Heav'n's Indulgence brooded on the Ground.

Georg. II.

Among numberleſs Deſcriptions of the Moderns, Mr. *Pope* has the following moſt delicate one:

In that ſoft Seaſon, when deſcending Show'rs
Call forth the Greens, and wake the riſing Flow'rs;
When op'ning Buds ſalute the welcome Day,
And Earth relenting, feels the genial Ray.

And again,

'Twas now the Seaſon, when the glorious Sun
His heav'nly Progreſs thro' the Twins *had run;*
And Jove, *exalted, his mild Influence yields,*
To glad the Glebe, and paint the flow'ry Fields.

Mr. *Thompſon* has made this Seaſon the Subject of an exquiſite Poem; in which, after a ſhort Invocation or figurative Addreſs in theſe Words ——

Come, gentle SPRING, ÆTHEREAL MILDNESS, *come,*
And from the Boſom of yon dropping Cloud,
While Muſic wakes around, veil'd in a Show'r
Of ſhadowing Roſes, on our Plains deſcend ——

He inſcribes the Poem; and ſoon after begins the magnificent Deſcription thus ——

At laſt from Aries *rolls the bounteous Sun,*
And the bright Bull *receives him. Then no more*
Th' expanſive Atmoſphere is cramp'd with Cold,
But full of Life, and vivifying Soul,
Lifts the light Clouds ſublime, and ſpreads them thin,
Fleecy and white o'er all-ſurrounding Heaven.
Forth fly the tepid Airs; and unconfin'd,
Unbinding Earth the moving Softneſs ſtrays.
Joyous th' impatient Huſbandman perceives
Relenting Nature. ——

And having ſung the Praiſes of the *Plough*, he conſiders the delightful Effects of this Seaſon on *vegetative Nature.*

Nor thro' the lenient Air alone, this Change
Delicious breaths, the penetrative Sun,
His Force deep-darting to the dark Retreat
Of Vegetation, ſets the ſteaming Pow'r

At large to wander o'er the verdant Earth,
In various Hues, but chiefly thee, gay green!
Thou ſmiling Nature's univerſal Robe!
United Light and Shade! where the Sight dwells
With growing Strength, and ever-new Delight!
From the moiſt Meadow to the brown-brow'd Hill,
Led by the Breeze, the vivid Verdure runs;
And ſwells, and deepens to the cheriſh'd Eye.

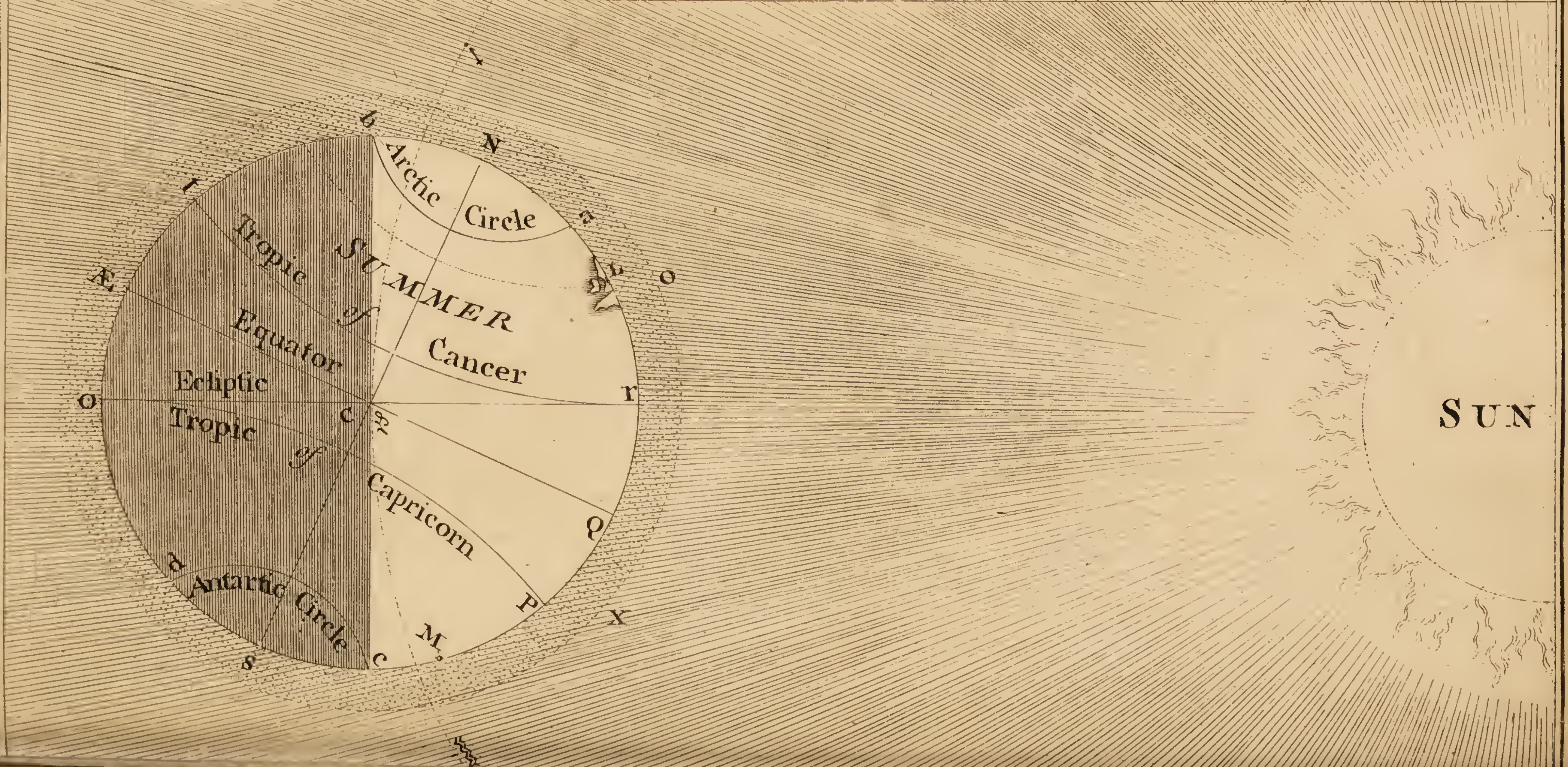
Having beautifully deſcribed the Vegetation and wond'rous Growth of all Kinds of Plants; he next deſcants on the Influence of the Spring on animated Bodies, and firſt on the *feathered Kind.*

Lend me your Song, ye Nightingales! O pour
The mazy running Soul of Melody
Into my varied Verſe! while I deduce,
From the firſt Note the hollow Cuckoo ſings,
The ſymphony of Spring, and touch a Theme
Unknown to Fame, the Paſſion of the Groves.
Juſt as the Spirit of Love is ſent abroad,
Warm thro' the vital Air, and on their Hearts
Harmonious ſeizes, the gay Troops begin,
In gallant Thought, to plume the painted wing;
And try again the long-forgotten Strain,
At firſt, faint warbled, but no ſooner grows
The ſoft Infuſion prevalent and wide,
Than, all alive, at once their Joy o'erflows
In Muſick unconfin'd. Up ſprings the Lark,
Shrill-voic'd, and loud the Meſſenger of Morn;
E'er yet the Shadows fly, he mounted ſings
Amid the dawning Clouds, and from their Haunts
Calls up the tuneful Nations. Every Copſe
Thick-wave, and Tree irregular, and Buſh
Bending with dewy Moiſture, o'er the Heads
Of the coy Choriſters that lodge within
Are prodigal of Harmony.

It would be tedious to purſue him thro' all his fine Reflections on the vernal Seaſon, and its agreeable and beneficent Effects on all the World. ——I fear I have tired your Patience already; but,

THE SUMMER SEASON.

Plate XXII.



but, my dear *Euphroſyne*, I know you'll forgive a Digreſſion of this Kind, were it much longer, in Complaiſance to the Muſes.

Euphroſ. I hear you with equal Patience and Pleaſure. — This happy Seaſon can't be too much extolled.——But, ſee, the Earth is moved far on; the Spring begins to give Way to Summer, which I ſuppoſe will here ſucceed, as it does in Nature.

Cleon. In the very ſame Manner. As the Middle of the Spring Seaſon is about the 20th of *March*, when the Sun (S) appears in the Beginning of *Aries* (♈); ſo about the Beginning of *May*, the Spring ends, and the Summer Seaſon commences, which we will next contemplate on the *Orrery*.

DIALOGUE X.

Of SUMMER.

Euphroſyne.

THE Earth being near advanced to *Capricorn* (♑) ſhews the Serenity of Spring is paſt, and the near Approach of Summer. ——— But ſince the Earth is ſtill at the ſame Diſtance from the Body of the Sun, I can't rightly conceive how it comes to paſs, that the Sun-beams are ſo much hotter than at other Times.

Cleon. To explain that is one great Deſign of the Orrery.— In order to which, you muſt conſider, and underſtand, that the principal Characteriſtics of *Summer* are *two*, *viz.* (1.) *The Days are then longeſt*; *and* (2.) *The Heat is moſt intenſe.* How the Days are now longeſt, I ſhall explain to you at large, after we have done with the Seaſons. — I ſhall now only ſhew you why the Heat is greater *with us* than at any other Time of the Year.

Euphroſ. Why do you ſay, *with us*, ſo emphatically, *Cleonicus?*

Cleon. Becauſe, with reſpect to the Earth in general, the Sun's Heat is nearly always the ſame; but greater or leſſer only in regard of ſome particular Place at ſome certain Seaſons of the Year, as with us when the Sun appears in *Cancer* (♋); for at that very Time it is coldeſt in ſome other Part of the Earth.

Euphroſ. But what I want to know is, how it comes to paſs, that it is ſometimes very hot, and ſometimes very cold at different Times of the Year in the ſame Place?

Cleon. The Reaſon of that will eaſily be underſtood, if you remember what I obſerved to you about the Axis of the Earth (N S) not being perpendicular to the Plane of the Ecliptic (*o r*) but inclined thereto; and alſo, that the Earth ſo moves as always to have its Axis parallel to itſelf, or pointing to the ſame Part of the Heavens.

Euphroſ. I remember that very well, and — now I look on the Earth, I readily ſee what follows, *viz.* the North Pole (N), by this Inclination of its Axis, is carried more and more towards the Sun, as it arrives nearer and nearer to the Beginning of *Capricorn* (♑).———

Cleon. Very good, my *Euphroſyne*; and when it comes there, you will obſerve, that all the Places of the Earth which have North Latitude are turned more directly towards the Sun than when in its firſt Poſition in the Spring. And, conſequently, the more directly the Sun's Rays fall on any Part, the thicker or denſer they will be, and therefore, ſo much the hotter. Thus, for Example, ſuppoſe a Parcel of Rays, *a b c d*, fall directly, or perpendicularly on any Plane, A B, and obliquely on another Plane, A C, 'tis evident, they will take up a ſmaller Space, *c d*, in the former, than *e f*, in the latter; and ſo their Action, *i. e.* their Heat would be much greater in the leſſer Space *c d*, than in the larger *e f*; and if, inſtead of Lines, we ſuppoſe *c d* and *e f* to be the Diameters of Surfaces, then the Heat on thoſe Surfaces will be inverſely as the Squares of the Diameter, *viz.* as the Square of *e f* to the Square of *c d*. And this would be the Caſe with reſpect to the Inhabitants of the Earth, if we were to regard the Sun's Rays only; but, as I ſaid, the greater Length of Day contributes to augment the Heat: And moreover, another Reaſon which I have not before mentioned, is, that the Rays do now paſs through a far leſs Portion of the Atmoſphere, and therefore, are not ſo much refracted and weakened by it, as when they fall more obliquely on the Earth, and ſo paſs thro' a greater Part of it.

Euphroſ. When you talk of the Atmoſphere, you go a little out of my Depth, *Cleonicus*; pray, explain that a little farther to me.

Cleon. I will. The Earth is ſurrounded on all Parts by a Body of Air of a ſpherical Form to a certain Height (which I have repreſented by the dotted Circumference about the Figure of the Earth in this little Scheme, for Illuſtration Sake) this Body of Air being filled with watry, &c. Particles, exhaled from the Earth, occaſions the Sun's Rays, in paſſing thro' it, to be variouſly refracted, and blended thro' its Subſtance, and the more ſo, the more obliquely they are received by it; and conſequently, the more their Action or Effect is weakened and abated on the Surface of the Earth.

Euphroſ. Pray give me an Example of this, *Cleonicus*; I ſhall then better apprehend you.

Cleon. You ſee the Earth is now juſt arrived to the firſt Scruple of *Capricon* (♑) where it has the ſame Poſition, with Regard to the Sun, as the Figure thereof has in this Scheme. At this Time the Days are longeſt, and the Sun's Rays fall moſt direct upon us, and therefore are ſtrongeſt in their immediate Effects, and therefore, this is the *Middle of Summer*, which you ſee happens about the 11th of *June*; for againſt that Day the Earth now ſtands in the *Orrery*.

Euphroſ. I ſee it does; and had you not better ſtop it there for ſome Time?

Cleon. Yes, I intend it. ——— Obſerve, in the Scheme, the Situation of the City of *London* L, the Poſition of the Earth, you ſee, at this Time turns all the Northern Hemiſphere (Q N Æ) as much towards the Sun as they can be, and more than at any other Time of the Year; and conſequently, the Sun's Rays fall on this Metropolis, at this Time, more directly than at any other; and their Paſſage thro' the Atmoſphere (O L) the ſhorteſt of all. And therefore all Things conſpire to make this the warmeſt, and moſt lightſome Seaſon of the Year with us.

Euphroſ. You have made the Matter ſo plain, that I ſhould be dull not to underſtand it tolerably well. ——— And I further obſerve, that in this Poſition of the Earth, all the Southern Hemiſphere (Q S Æ) is turned as much away from the Sun as can be; and ſo, I preſume, it muſt be Winter with all thoſe who live in Southern Latitude, at this preſent Time. ——

Cleon. You judge very right; for ſuppoſe the Place M hath its South Latitude Q M equal to the North Latitude of *London* Q L; the Days will there be the ſhorteſt, the Sun's Rays will fall on it moſt obliquely, and their Paſſage thro' the Atmoſphere (X M) will then be greateſt of all; and conſequently, every Thing there combines to make it the coldeſt Seaſon of the Year; *i. e.* their *Winter*; all which is, I think, evident from the Scheme.

Euphroſ. It is ſo; and I never conſidered 'till now, *that when it is Summer in one Part of the Earth, it is Winter in that which is equally diſtant from the Equator on the other Side.*

Cleon. I am glad to ſee you apprehend it now; for that is indeed the Caſe; and thus, I think, you have as compleat an Idea of the Reaſons of the *Summer-Seaſon*, as at preſent I can give you; tho' I may have Occaſion hereafter to ſay ſomething further on this Head. One Thing yet remains, and that is, to ſhew you what Parts of the Earth participate of the Sun's Light and Heat, and which are excluded from it, in the preſent Situation thereof. For it is not now, as in the Spring, when all the Earth received the enlivening Influences of the Sun-beams in the Space of 24 Hours, and had an equal Share of his Abſence; but now ſome Parts enjoy *continual Day*, while others are overwhelmed in Darkneſs of equal Duration.

Euphroſ. This, I ſuppoſe, you can ſhew by *the Taper and darkened Room, as before.*

Cleon. Yes, my *Euphroſyne*; —— I'll ſhut the Windows — and ſetting the Candle in the Place of the Sun, that the Light may fall on the Earth —— I put the Machine in Motion, —— and you ſee the *Parts of the* Terrella *illuminated*, either *wholly*, or *in Part*, or *not at all*, in every *diurnal Rotation* about its Axis.

Euphroſ. I do; and it is very curious to behold! ——— I ſee all the Parts about the North Pole (N) as far as the *Artic Circle (ab)* conſtantly enlightened during the whole Rotation. ——— On the contrary, I obſerve all the Parts about the South Pole, to the *Antartic Circle (c d)*, are wholly in the dark ——— while all other Parts of the Earth, the nearer they are to the

North Pole, or rather the *Artic Circle (a b)*, the more they ſhare of the Sun's Light, in each Revolution of the Earth.

Cleon. Your Obſervations are all very juſt, and take in almoſt all I intended; ——— but farther, you ſee, that, as the Earth advances in her annual Orbit from *Capricorn* towards *Aries* (♈), the North Pole (N) recedes from the Sun; and leaves, by Degrees, thoſe Places within the Artic Circle *(ab)* remoteſt from the Polar Point, to ſhare a Part of the Night; and the more largely ſo, as they are more remote from the Pole N.

Euphroſ. Yes, all this I ſee, *Cleonicus*, with infinite Pleaſure. ——— And farther obſerve, that the ſame Parts about the South Pole (S) which before lay obſcured in Night, are in the ſame Manner reſtored by Degrees to cheriſhing Light and Day.

Cleon. I do aſſure you, my *Euphroſyne*, without a Compliment, ſuch is your Perſpicuity, that nothing I know of worthy Notice, has eſcaped your Eye, in Relation to this Seaſon, and the *Phænomena* thereof, by the Orrery. ——— We will now again throw open the Windows, and reſtore *Phœbus* to his central Throne, that he may again preſide o'er the moving Orbs of the Syſtem. ——— The Earth keeps journeying on; ——— ſhe is now got near the Beginning of *Aquarius* (♒) ——— and the *Summer* declines towards *Autumn*.

Euphroſ. What Time do you ſuppoſe the *Summer* to end, and *Autumn* begin?

Cleon. About the Beginning of *Auguſt*; when the Sun appears about the *Middle* of *Leo* (♌), and the Earth is in the Middle of *Aquarius*, where in a few Minutes you will ſee her.

Euphroſ. If the Summer expires about *Auguſt*, how comes it to paſs, that that is, for the moſt Part, the hotteſt Month in the Year?

Cleon. You may conceive the Reaſon of that after this Manner: During the Summer Months, the Days, being longer than the Nights, pour more Rays, or Heat upon the Earth, than the Coldneſs of the Nights can extinguiſh; and therefore, there will every Day be an Exceſs of Heat remaining in the Earth; and this being every Day augmented thro' the whole Summer, muſt be very conſiderable at the latter End; when the Earth will be heated, not only by the Sun-beams falling on it, but alſo by thoſe which remain in it in great Quantity, the Forces of both which conjoined, produce thoſe almoſt inſupportable, ſultry Heats, which uſher in the *Autumn*.

Euphroſ. What you ſay, *Cleonicus*, ſeems very conſonant to Reaſon; and now I have a much more extenſive and rational Idea of this Seaſon, and its various Qualities than I had before. ——'Tis true, the Summer Heat is ſo exceſſive, as makes it, in Point of Pleaſure, yield to the Spring. ——

Cleon. Yes it does ſo; but even thoſe intenſe Heats, which to us are irkſome and almoſt unſufferable, are in Nature as beneficial and neceſſary as the Temperament of any other Seaſon: For hereby all the Flowers, Fruits, and Seeds of Trees and Plants, in every Clime, are brought to Maturity and Perfection. ——But the ſpecial Advantages of this, as well as the other Seaſons, are moſt beautifully deſcribed by the Poets. ——Thus Sir *Richard Blackmore*:

The Heats of Summer Benefits produce,
Of equal Number and of equal Uſe.
The ſprouting Births and beauteous vernal Bloom,
By warmer Rays to ripe Perfection come;
Th' auſtere and pond'rous Juices they ſublime,
Make them aſcend the porous Soil, and climb
The Orange Tree, the Citron, and the Lime:
Which, drank in Plenty by the thirſty Root,
Break forth in painted Flowers and golden Fruit.
They explicate the Leaves, and ripen Food
For the Silk-labourers of the Mulb'ry Wood:
And the ſweet Liquor on the Cane beſtow,
From which prepar'd the luſcious Sugars flow:
With gen'rous Juice enrich the ſpreading Vine,
And in the Grape digeſt the ſprightly Wine.
The fragrant Trees, which grow by Indian *Floods,*
And in Arabia's *aromatic Woods,*
Owe all their Spices to the Summer's Heat,
Their gummy Tears, and odorif'rous Sweat.
Now the bright Sun compacts the precious Stone,
Imparting radiant Luſtre, like his own:
He tinctures Rubies with their roſy Hue,
And on the Saphire ſpreads a heav'nly blue;

For the proud Monarch's dazzling Crown prepares
Rich, orient Pearl, and adamantine Stars.

Creation, Lib. II.

And Mr. *Thompſon*, in his admirable Poem:

When the bright Virgin *gives the beauteous Days,*
And Libra *weighs in equal Scales the Year;*
From Heav'n's high Cope, the fierce Effulgence ſhook,
Of parting Summer, a ſerener Blue,
With golden Light irradiate, wide inveſts
The happy World. Attemper'd Suns ariſe,
Sweet-beam'd, and ſhedding oft thro' lucid Clouds
A pleaſing Calm; while broad, and brown, below,
Unbounded Harveſts hang the heavy Head.
Rich, ſilent, deep, they ſtand; for not a Gale
Rolls its light Billows o'er the bending Plain;
A Calm of Plenty! 'till the ruffled Air
Falls from its Poize, and gives the Breeze to blow.
Rent is the fleecy Mantle of the Sky;
The Clouds fly different; and the ſudden Sun,
By Fits effulgent, gilds th' illumin'd Field,
And black by Fits the Shadows ſweep along.
A gayly checker'd, wide extended View,
Far as the circling Eye can ſhoot around,
Convolv'd, and toſſing in a Flood of Corn.

DIALOGUE XI.

Of AUTUMN.

Euphroſ.

I Think we have had a very pleaſing Speculation on the two firſt Seaſons, *Spring* and *Summer*; and they ſucceed ſo faſt in this Machine, that *Autumn* is already very far advanced upon us, the Earth being ſome Degrees in *Piſces* (♓). ———

Cleon. Yes, the Days now grow ſhorter, and the Nights lengthen; the Parts towards the North Pole, and within the Arctic Circle, are now carried farther and farther from the Sun, as thoſe, towards and about the South Pole, are turned more and more to its Beams. And thus, with the former, the Summer-Heats, as with the latter, the Winter-Colds abate, and Nature is again reſtored to an *Equilibrium*, or a due and equal Diſtribution of Light, and Heat; Day and Night, to all Parts of the Earth equally diſtant from the *Equator*, on each Side. And this obtains, when the Earth enters *Aries* (♈), or the Sun is ſeen in *Libra* (♎).

Euphroſ. Tho' there be an Equality of Days and Nights, *&c.* in *Autumn*, as in the *Spring*; yet it is not near ſo pleaſant a Seaſon. The Trees and Fields are then green and blooming; now brown and fading. Nature ſeems now ſickening, and drawing towards its Diſſolution; but then revived and regenerated in its various Produce. Yet I can't ſay, but *Autumn* has its Pleaſures too; the Harveſt-Fields of ripened Grain, the Labourers performing their ſeveral Taſks therein, the *autumnal* Seaſons of Ploughing and Sowing, and various other Things, make rural Scenes delightful at this Seaſon. ——— I am greatly delighted with *Homer*'s beautiful Deſcription of the HARVEST-FIELD —

Another Field roſe high with waving Grain;
With bended Sickles ſtand the Reaper-train:
Here ſtretch'd in Ranks the levell'd Swarths are found,
Sheaves heap'd on Sheaves, here thicken up the Ground.
With ſweeping Stroke the Mowers ſtrow the Lands;
The Gath'rers follow, and collect in Bands;
And laſt, the Children, in whoſe Arms are borne
(Too ſhort to gripe them) the brown Sheaves of Corn.
The ruſtic Monarch of the Field deſcries,
With ſilent Glee, the Heaps around him riſe.
A ready Banquet on the Turf is laid,
Beneath an ample Oak's expanded Shade;
The Victim-ox the ſturdy Youth prepare;
The Reaper's due Repaſt, the Womens Care.

And of the VINTAGE ——

Next, ripe in yellow Gold, a Vineyard *ſhines,*
Bent with the pond'rous Harveſt of its Vines;
A deeper Dye the dangling Cluſters ſhow,
And curl'd on ſilver Props, in Order glow:
A darker Metal mix'd, intrench'd the Place,
And Pales of glitt'ring Tin th' Encloſure grace.
To this, one Path-way gently-winding leads,
Where march a Train with Baſkets on their Heads.
(Fair Maids and blooming Youths) that ſmiling bear
The purple Product of th' autumnal Year.
To theſe a Youth awakes the warbling Strings,
Whoſe tender Lay the Fate of Linus *ſings;*
In meaſur'd Dance behind him move the Train,
Tune ſoft the Voice, and anſwer to the Strain.

And that of PLOWING ſeems to be admirably fine. ——

A Field deep furrow'd next the God deſign'd,
The third Time labour'd by the ſweating Hind:
The ſhining Shares full many Plowmen guide,
And turn their crooked Yokes on either Side,
Still as at either End they wheel around,
The Maſter meets them with his Goblet crown'd;
The hearty Draught rewards, renews their Toil;
Then back the turning Plough-ſhares cleave the Soil:
Behind, the riſing Earth in Ridges roll'd,
And ſable look'd, tho' form'd of molten Gold.
Pope's Homer, B. XVIII.

Cleon. The Lines you repeat, are the moſt beautiful Part of *Homer*'s Deſcription of *Rural Life.* —— The *autumnal Seaſon* is the chiefeſt Time of Action abroad. And hence the Poets, ſince *Homer*, have always made the Labours of the Harveſt the chief Theme of their Lays, whenever this Seaſon has been their Subject. —— Thus Sir *Richard Blackmore:*

Next Autumn, when the Sun's withdrawing Ray
The Night enlarges, and contracts the Day,
To crown his Labour to the Farmer yields
The Yellow Treaſures of his fruitful Fields;
Ripens the Harveſts for the crooked Steel,
(While bending Stalks the rural Weapon feel)
The fragrant Fruit for the nice Palate fits,
And to the Preſs the ſwelling Grape ſubmits.
Creation, B. II.

Virgil, from the various Incidents of this Seaſon, gives many ſingular and notable Epithets thereto; thus, addreſſing his 2d *Georgic* to *Bacchus,* he ſays,

To thee his Joys the Jolly Autumn *owes,*
When the fermenting Juice the Vat o'erflows.

In another Place, on Account of the *Vintage* at this Time of the Year, he calls it the *Vine-leav'd Autumn*;* and becauſe the Sun now enters *Libra,* or the Balance, he makes *Autumn weigh the Year.*

Now ſing we ſtormy Stars, when Autumn weighs
The Year, and adds to Nights, and ſhortens Days;
And Suns declining ſhine with feeble Rays. Geor. B. I.

Laſtly, he calls *Autumn* the *Evening of the Year*; as if *Spring* and *Summer* were the *Morning* and *Noon,* and *Winter* the *Night* thereof.

——— *The Evening of the Year;*
When Woods, with Juniper and Cheſnuts crown'd,
With falling Fruits and Berries paint the Ground;
And laviſh Nature laughs, and ſtrews her Stores around.

Euphroſ. This Seaſon of the Year, I think, is remarkable upon ſome other Accounts; for Inſtance, the *Harveſt Moon,* which I have heard much Talk of, but ſhould be glad to know the Reaſon of it better than I do: Can you explain it, *Cleonicus?*

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* Autumnus pampineus.

Cleon. That which is called the *Harveſt*, or *Shepherd's Moon*, is a very conſiderable *Phænomenon*; but I chuſe to defer the Explication of it 'till we come to the Uſe of the *Celeſtial Globe*, where it will be much eaſier underſtood than by the *Orrery*.

Euphroſ. I am obliged to you, *Cleonicus*. —— Is there any Thing more to be noticed at this Seaſon of the Year? For I would not tire you with Impertinencies.

Cleon. I need not obſerve to you, that the Ancients made much more ado about this Seaſon of the Year than we in this Age. They had now their Feſtivals of *Bacchus* and *Pomona*, the Deities of their Vintage and Orchards; and their extravagant Mirth, Rejoicings, and Revels, on theſe Occaſions, ought rather to be ſuppreſſed, than related to the Diſgrace of our Species. And it were to be wiſhed, indeed, that the Harveſt-Populace of the preſent Age were more ſenſible of the Dignity of human Nature; for they would then not debaſe it ſo much as they do, by ſome of their antique and ridiculous Cuſtoms at this Seaſon of the Year in many Parts of *England*. —— But we ſhall dwell no longer on this diſagreeable Topic.

DIALOGUE XII.

Of WINTER.

Cleonicus.

YOU now obſerve, my *Euphroſyne*, the *Autumnal Seaſon* is over, in the *Orrery*, and the *Winter* begins; which brings on the cold Concluſion of the Year.

Euphroſ. I can ſcarce help ſhuddering at the Mention of Winter; and methinks, the northern Parts of the Globe ſeem to enter upon a horrid State —— Gloom and Darkneſs are now their Portion —— They are turning farther and farther from the Sun, which now begins to chear the inferior Regions of the Earth. ——— How diſmal is the Face of Winter, even in Machinery!

Cleon. A heavy and dreary Seaſon, indeed! The Sun, as the Earth moves towards *Cancer* (♋), declines from its meridian Height, and the Polar Parts go gradually into Darkneſs; till at length, when the Earth is got to *Cancer* (♋), the northern frigid Zone will be over-whelmed in Obſcurity, like that of the Evening Twilight.

Euphroſ. So I obſerve. ——— And at the ſame Time, I ſee the ſouthern Pole, and its Regions, become more and more illuminated; and when the Sun has reached *Cancer*, I ſuppoſe the whole polar Circle will enjoy its Light uninterruptedly for a While.

Cleon. It will ſo for one Day; and then the Sun will begin to leave the Pole, and the Parts about it by Degrees. —— Thus all Things will appear reverſe to what they were in the Summer Seaſon. ——— The Days are ſhort, and the Nights long; which you plainly diſcern by the northern Parallels continuing but a ſhort Time in the Light, or illumined Hemiſphere, and a much longer Time in the Dark one. ——— And therefore, by a natural Conſequence, the Cold muſt greatly increaſe in all north Latitudes, and this, together with the Shortneſs of Days, conſtitute the Nature of this Seaſon, and make what we call *Winter*; which is one great Cauſe of the encreaſing Coldneſs of this Seaſon.

Euphroſ. You have already taught me to underſtand, that as the Sun's Rays falling more directly on us in Summer helped to augment the Heat of that Seaſon; ſo his Rays falling now more obliquely on our Parallel, and all the northern ones, conduce to increaſe the Cold, and render it more intenſe.*

Cleon. Very good, you remember and apprehend the Thing well. ——— But ſee, the Earth has now reached the critical Point,

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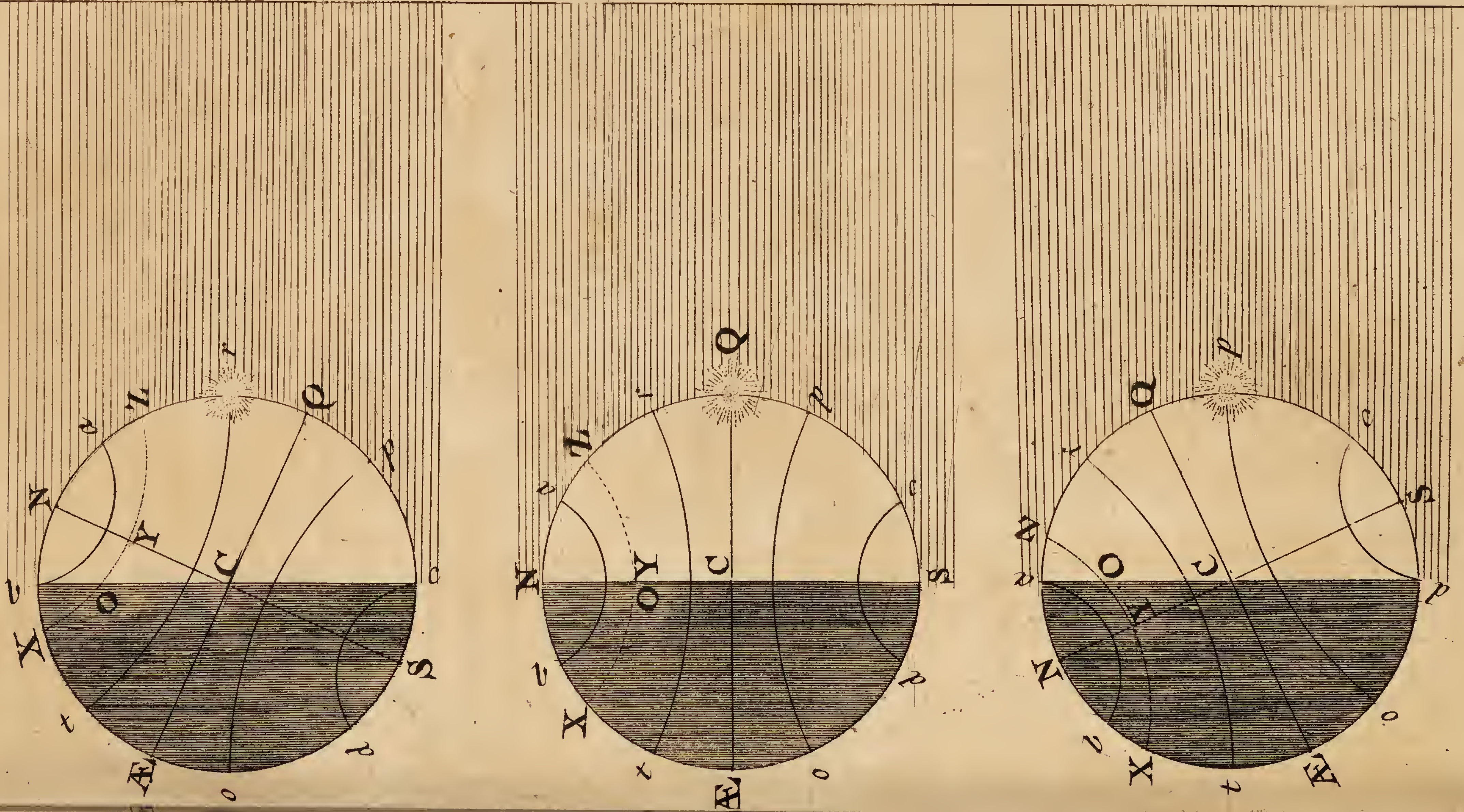
* The Reader, by caſting his Eye on the Diagram in Plate XXIV, will ſee an exact and natural Repreſentation of the Earth in its Winter-Situation in the Orrery, and ſuch as it really has in its Orbit, with reſpect to the Sun, in the Middle of Winter; from whence as eaſy an Idea of the concurring Cauſes of Cold in this Seaſon may be collected, as from a View of the Earth itſelf in the Machine; and indeed there is no other Way by which this important Affair can be ſo juſtly and naturally repreſented to the Underſtanding. I hope no one will think he has too much Aſſiſtance in a Matter ſo little underſtood, as the *Rationale of the Seaſons.*

The Different Lengths of DAYS & NIGHTS.

Plate XXIII.



Point, I mean the Beginning of *Cancer*, ——— and now is the Depth of Winter to all the northern Latitudes, and the Height of Summer to all the ſouthern Parts. ——— The Sun, you obſerve, appears now to enter *Capricorn* (♑). ——— The higheſt Part of the enlightened Hemiſphere, you ſee, reaches but to the *Arctic Circle*, and leaves all beyond it to the Pole in Darkneſs, or rather Twilight. ——— For, as I ſhall ſhew you hereafter on the Globe, there are but *five Degrees* about the Pole, which are now in abſolute Darkneſs.

Euphroſ. Well, 'tis very admirable to ſee Nature thus mimicked and repreſented by Art! To ſee the Change and Succeſſion of Seaſons all performed in ſo ſhort a Space, is wonderous and delightful. ——— The Earth, I ſee, is advancing a-pace towards the *Vernal Equinox*, whence it firſt ſet out; and there our artificial Year will end.

Cleon. It will; —— and as the Earth moves on, you'll ſee, by Means of the Paralleliſm of the Earth's Axis, how all the northern Parts of the Pole are gradually turned towards the Sun again, and re-enjoy his Beams; — how the Days lengthen, and the Nights decreaſe, contrary to what happens beyond the Equator; — and how the chilly, darkſome Seaſon moves off, ſucceeded by the ſmiling Spring. — The Qualities of this Seaſon afford a copious Theme to the Poets; among whom we find many beautiful Deſcriptions of Winter; the firſt and principal of which is that of old *Homer*, in his 12th *Iliad*, which is thus,

> *As when ſharp* Boreas *blows abroad, and brings*
> *The dreary* WINTER *on his frozen Wings*;
> *Beneath the low-hung Clouds the Sheets of Snow*
> *Deſcend, and whiten all the Fields below.*

And a little after;

> ——— *High* Jove *his ſharp Artillery forms,*
> *And ope's his cloudy Magazine of Storms*;
> *In Winter's bleak uncomfortable reign,*
> *A ſnowy Inundation hides the Plain*;
> *He ſtills the Winds, and bids the Skies to ſleep*;
> *And pours the ſilent Tempeſt thick and deep:*

And firſt the Mountain-Tops are cover'd o'er,
Then the green Fields, and then the ſandy Shore;
Bent with the Weight, the nodding Woods are ſeen,
And one bright Waſt hides all the Works of Men.
The circling Seas alone abſorbing all,
Drink the diſſolving Fleeces as they fall.
So from each Side increas'd the ſtony Rain,
And the white Ruin riſes o'er the Plain.

Euphroſ. This is very beautiful, indeed! Pray, what does *Virgil* ſay on this cold Subject?

Cleon. The Theme is a frozen one, 'tis true; but it does not abate the Poet's Fire. —— For he very copiouſly deſcribes the Winter and all its various Incidents in the following admirable Manner; where ſpeaking of the northern Climates, he gives us the Deſcription of a *Scythian* Winter in the ſubſequent Lines.

Early they ſtall their Flocks and Herds; for there
No Graſs the Fields, no Leaves the Foreſts wear:
The frozen Earth lies bury'd there, below
A hilly Heap, ſev'n Cubits deep in Snow;
And all the weſt Allies of ſtormy Boreas *blow.*
The Sun, from far, peeps with a ſickly Face;
Too weak the Clouds, and mighty Fogs to chace;
When up the Skies he ſhoots his roſy Head,
Or in the ruddy Ocean ſeeks his Bed.
Swift Rivers are with ſudden Ice conſtrain'd;
And ſtudded Wheels are on its Back ſuſtain'd.
An Hoſtry now for Waggons, which before
Tall Ships of Burden on its Boſom bore.
The brazen Cauldrons with the Froſt are flaw'd;
The Garment, ſtiff with Ice, at Hearths is thaw'd;
With Axes firſt they cleave the Wine, and thence,
By Weight, the ſolid Portions they diſpenſe.
From Locks, uncomb'd, and from the frozen Beard,
Long Iſicles depend, and crackling Sounds are heard.
Mean Time, perpetual Sleet, and driving Snow
Obſcure the Skies, and hang on Herds below:

The ſtarving Cattle periſh in their Stalls,
Huge Oxen ſtand incloſ'd in wintry Walls
Of Snow congeal'd; whole Herds are buried there
Of mighty Stags, and ſcarce their Horns appear;
The dext'rous Huntſman wounds not there a-far,
With Shafts or Darts, or makes a diſtant War
With Dogs; or pitches Toils to ſtop their Flight;
But cloſe engages in unequal Fight.
And while they ſtrive, in vain, to make their Way
Through Hills of Snow, and pitifully bray;
Aſſaults, with Dint of Sword, or pointed Spears,
And homeward, on his Back, the joyful Burden bears.
The Men to ſubterranean Caves retire;
Secure from Cold, and crowd the chearful Fire:
With Trunks of Elms and Oaks, the Hearth they load,
Nor tempt th' Inclemency of Heav'n abroad;
Their jovial Nights in Frolic and in Play
They paſs, to drive the tedious Hours away,
And their cold Stomachs with crown'd Goblets cheer,
Of windy Cyder, and of barmy Beer.
Such are the cold Raphëan *Race; and ſuch*
The ſavage Scythian, *and the* German Dutch;
Where Skins of Beaſts the rude Barbarians wear,
The Spoils of Foxes and the furry Bear.

Dryd. Virg. Georg. III.

And thus Sir *Richard Blackmore.*

At length, forſaken by the ſolar Rays,
See blooming Nature ſickens and decays,
While Winter all his ſnowy Stores diſplays:
In hoary Triumph unmoleſted reigns
O'er barren Hills, and bleak, untrodden Plains.
Hardens the Glebe, the ſhady Grove deforms,
Fetters the Cold, and ſhakes the Air with Storms;
Now active Spirits are reſtrain'd with Cold,
And Priſons crampt with Ice the genial Captives hold.
The Meads their flow'ry Pride no longer wear,
And Trees extend their naked Arms in Air;

The frozen Furrow, and the fallow Field,
Nor to the Spade, nor to the Harrow yield.

Creation, Lib. II.

The Approach of *Winter* is alſo thus admirably repreſented by Mr. *Thompſon*, on the Seaſons.

Now when the chearleſs Empire of the Sky
To Capricorn *the* Centaur Archer *yields,*
And fierce Aquarius *ſtains th' inverted Year;*
Hung o'er the fartheſt Verge of Heav'n, the Sun
Scarce ſpreads o'er Æther the dejected Day.
Faint are his Gleams and ineffectual ſhoot
His ſtruggling Rays, in horizontal Lines,
Thro' the thick Air; as cloath'd in cloudy Storm,
Weak, wan and broad, he ſkirts the ſouthern Sky;
And, ſoon deſcending, to the long, dark Night,
Wide ſhading all, the proſtrate World reſigns.
Nor is the Night unwiſh'd; while vital Heat,
Light, Life, and Joy the dubious Day forſake.
Mean Time, in ſable Tincture, Shadows vaſt,
Deep-ting'd and damp, and congregated Clouds,
And all the vapoury Turbulence of Heaven
Involve the Face of Things. Thus Winter falls
A heavy Gloom, oppreſſive o'er the World,
Thro' Nature ſhedding Influence malign,
And rouſes up the Seeds of dark Diſeaſe.
The Soul of Man dies in him, loathing Life,
And black with more than melancholy Views.
The Cattle droop; and o'er the furrow'd Land,
Freſh from the Plough, the dun, diſcolour'd, Flocks,
Untended ſpreading, crop the wholeſome Root.
Along the Woods, along the mooriſh Fens,
Sighs the ſad Genius *of the coming Storm;*
And up among the looſe disjointed Cliffs,
And fractur'd Mountains wild, the brawling Brook,
And Cave, preſageful, ſend a hollow Moan,
Reſounding long in liſt'ning Fancy's Ear.

Euphroſ. Well, *Cleonicus*, the Pleaſure which theſe Converſations on the Seaſons afford me are inexpreſſible. Their Nature explained by the Orrery, and their Properties and Qualities as finely deſcribed by the Poets, give me perfect Ideas thereof; ſuch as I ſhould never have otherwiſe been able to have attained. — But ſee, the Year is compleated, and the Evening is ſpent. — The Machine may therefore reſt for this Time. —— And, pray, *Cleonicus*, what do you propoſe for the next Speculation?

Cleon. I purpoſe to ſhew you next, the *Theory of Day and Night*, the Alternation, and various Length of each, in every Seaſon of the Year; and that in the ſame Manner by the Orrery, as I have explained to you the Seaſons.

DIALOGUE XIII.

The THEORY *of* DAY *and* NIGHT, *explained by the* ORRERY.

Euphroſyne.

SO you think, *Cleonicus*, the Orrery the apteſt and beſt Machine for explaining the Nature and Difference of *Night* and *Day*. ———

Cleon. Undoubtedly, 'tis the beſt Inſtrument for that Purpoſe ever yet invented. For here you ſee the very Thing itſelf in Miniature.———Here the Taper is the Sun, illuminating one Half of this ſmall, terraqueous Globe, which repreſents the Earth; having all the Parts of Land and Water duly repreſented on it, with all the Meridians and Parallels of Latitude.— As it moves in its annual Courſe, you obſerve it turns about its own Axis; and is furniſhed with an Hour-Circle and Index for meaſuring the Time. All which Things are now to be regarded in the Repreſentation of Day and Night by the Machine.

Euphroſ. Theſe Things I ſhall readily attend to. ——— Therefore, put the Machine in Order, for the Experiment, and I'll put to the Window-ſhutters to darken the Room.———

Cleon. Stay a little, 'till I have placed the Earth in its proper Poſition for ſhewing the ſhorteſt Night and longeſt Day of the Year; and that is, in the *Beginning of Capricorn,* when the Sun will appear to enter *Cancer.* —— In the next Place, we will put a very ſmall Patch on the Place of *London,* which, by its Rotation, will ſhew the Parallel of *London* (X Y Z), deſcribed in each Revolution of the Earth about its Axis. —— Laſtly, to bring the Patch to that Part of the Meridian (X) which is oppoſite to the Sun; and ſet the Hour-Index at 12 preciſely. —— Theſe Things being done, you may darken the Room as ſoon as you pleaſe, and then I'll put the Inſtrument in Motion.

Euphroſ. 'Tis done. ——

Cleon. Obſerve the Earth equally divided into a light and dark Hemiſphere, which repreſent *Day* and *Night*; as the Meridian paſſes over the Middle Part of each; ſo it ſhews the *Noon,* or *Mid-day* to all Parts under it at the one, and *Mid-night* to all Parts under it in the other; among which you ſee the Patch, or *London* (at X). — I'll now ſet the Machine a-going: —— Obſerve the Earth revolving about its Axis from *Weſt* to *Eaſt.**

Euphroſ. I do, with Pleaſure, behold it; and I obſerve, that the Poſition of the Earth's Axis is ſuch, as will bring *London* ſoon out of the dark Hemiſphere into the enlightened one.

Cleon. It will ſo; and I need not tell you, that that will be the Time from *Mid-night* to *Sun-riſing,* or the Length of Half the Night, at that Time. Obſerve nicely the Time when the Patch begins to enter the Light.

Euphroſ. I will. —— It will not be long I ſee. —— It is now juſt come to the Point (O) or Circle of Light, —— and the Index is at $3^h\ 47'$.

Cleon.

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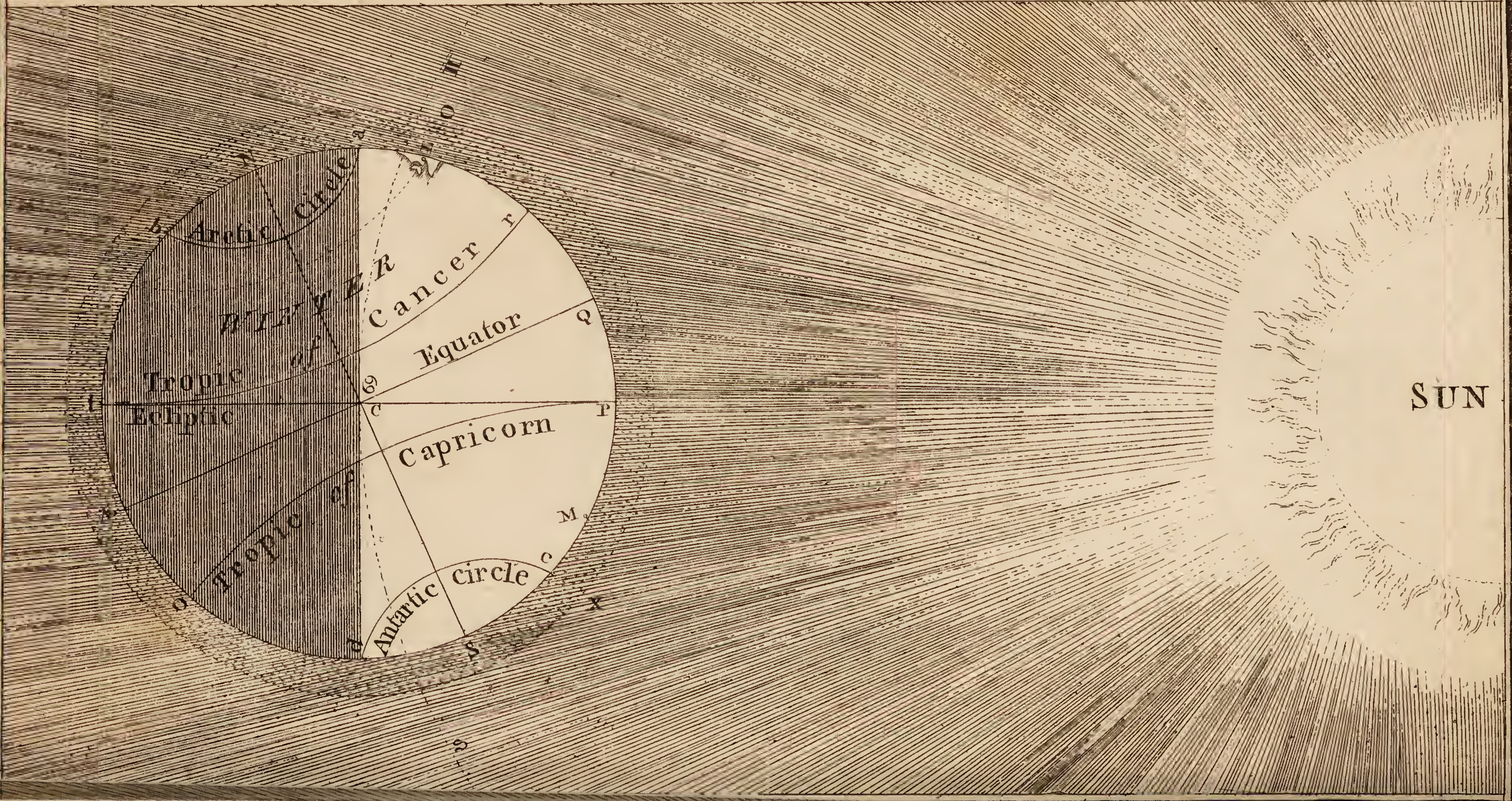
* As ſome of our Readers may not have ſeen an Orrery, and others may not particularly remember the Phænomena of *Day and Night* which they ſaw repreſented in it, I have judged it neceſſary to add a Diagram thereof (in Plate XXIII.) to aſſiſt the Underſtanding and Memory, in which, by a bare Inſpection, all the Variety of the Alternations of Day and Night in the Summer, Equinoxial and Winter Seaſons, is, it is preſumed, very eaſy to be underſtood; and in a good Meaſure, ſuch a Print may ſupply the Want of an Orrery, or other Inſtrument for this Purpoſe.

THE WINTER SEASON.

Plate XXIV.



Cleon. That is the *Time of Sun-riſing* on the 10th of *June*, and is the Morning of the Day. —— A Time very delightful in Summer, and is a favourite Theme with the Poets, who have all given us beautiful Deſcriptions thereof, particularly in the following Inſtances.

Thus *Virgil,*

Now roſe the ruddy Morn from Tithon's *Bed,*
And with the Dawn of Day the Skies o'erſpread ;
Nor long the Sun his dayly Courſe withheld,
But added Colours to the World reveal'd.

Thus *Garth,*

Aurora, *on Eteſian Breezes borne,*
With bluſhing Lips breaths out the ſprightly Morn.
Each Flow'r in Dew their ſhort liv'd Empire weeps,
And Cynthia *with her lov'd* Endymion *ſleeps.*

And *Homer* thus finely perſonates the Morn in the following Diſtich :

Now roſy Morn aſcends the Court of Jove,
Lifts up her Light, and opens Day above.

Alſo Mr. *Thomſon*'s Deſcription of *Sun-riſing* is too fine not to be taken Notice of.

Fierce flaming up the Heavens, the piercing Sun
Melts into limpid Air the high-rais'd Clouds,
And Morning Miſts, that hover'd round the Hills,
In parti-colour'd Bands ; till all unveil'd
The Face of Nature ſhines, from where Earth
Far-ſtretch'd around to meet the bending Spheres.
Seaſons. 74.

Euphroſ. Theſe are very beautiful and natural Deſcriptions, which, while you have been repeating, the Patch has got good Part of the Way towards the Meridian of Noon.

Cleon. I ſee it is —— and thus the Sun riſes gradually higher and higher to the Inhabitants of *London*, till the Patch comes under the Meridian (at *z*) where the Sun is at its greateſt Meridian Height in the Tropic of *Cancer* (at *r.*) This makes the *Noon* of the Day thus admirably deſcribed by the laſt mentioned Poet..

> *'Tis raging Noon; and, vertical, the Sun*
> *Darts on the Head direct his forceful Rays*
> *O'er Heaven and Earth, far as the ranging Eye*
> *Can ſweep, a dazzling Deluge reigns; and all*
> *From Pole to Pole is undiſtinguiſh'd Blaze.*
> *In vain the Sight, dejected to the Ground,*
> *Stoops for Relief; thence hot aſcending Steams*
> *And keen Reflection pain. Deep to the Root*
> *Of Vegitation parch'd, the cleaving Fields*
> *And ſlipp'ry Lawn an arid Hue diſcloſe,*
> *Blaſt Fancy's Blooms, and wither even the Soul.*
> *Echo no more returns the chearful Sound*
> *Of ſharp'ning Scythe: The Mower ſinking heaps*
> *O'er him the humid Hay, with Flowers perfum'd,*
> *And ſcarce a chirping Graſs-hopper is heard*
> *Thro' the dumb Mead; diſtreſsful Nature pants.*
> *The very Streams look languid from afar;*
> *Or thro' th' unſhelter'd Glade, impatient, ſeem*
> *To hurl into the Covert of the Grove.*
>
> Seaſons, Page 81.

Euphroſ. It is now juſt Noon in the Orrery, but far different from that you have now been deſcribing. — Here every Thing is quiet and ſerene; no ſcorching Sun, no ſweating, fainting Swains. —— How inoffenſively, as well as pleaſant, is the moſt irkſome Part of the Day here repreſented by Art!

Cleon. Very true, Siſter; we here obſerve the Hours of a Summer's Day paſs without the Fatigue and Pain of enduring it. ——— But Night comes ſtealing upon us; the Patch approaches the Confines of Darkneſs, and the Sun as gradually declines. ———You will obſerve, it takes the ſame Time in paſſing over this Half of the enlightened Hemiſphere as it did the other, *viz.* 8¼ Hours nearly; which, therefore, makes the longeſt Day 16½ Hours at *London*.

Euphroſ. I ſee what you ſay is Fact. —— The Sun is now juſt entering the Shades; and the Index points at viii. 13. —— How conſiſtent is Art with Nature!

Cleon. Nature is the Contrivance of an infinitely wiſe Artiſt; if we poor Mechanics can fabricate an artificial World ſo exactly, it is Nothing wonderful to ſee ſuch Beauty, Order, and Harmony in the Mundane Syſtem. ——

The Cloſe of the Day is thus beautifully deſcribed by *Homer*:

As when the Morn, refulgent Lamp of Night,
O'er Heav'ns clear Azure ſpreads her ſacred Light.
When not a Breath diſturbs the deep Serene,
And not a Cloud o'ercaſts the ſolemn Scene:
Around her Throne the vivid Planets roll,
And Stars unnumber'd gild the glowing Pole,
O'er the dark Trees a yellower Verdure ſhed,
And tip with Silver ev'ry Mountain's Head;
Then ſhine the Vales, the Rocks in Proſpect riſe,
A Flood of Glory burſts from all the Skies;
The conſcious Swains rejoicing in the Sight,
Eye the blue Vault, and bleſs the uſeful Light.

The Setting of the Sun is thus elegantly deſcribed by Mr. *Thomſon.*

Low walks the Sun, and broadens by Degrees
Juſt o'er the Verge of Day. The riſing Clouds
Aſſembled gay, a richly gorgeous Train,
In all their Pomp attend his ſetting Throne:
Air, Earth, and Ocean ſmile immenſe; and now,
As if the weary Chariot ſought the Bow'rs
Of Amphitrite; and her tending Nymphs,
(So Grecian *Fable ſung) he dips his Orb;*
Now half immers'd; and now a golden Curve
Gives one bright Glance, then total diſappears.

This is followed by a Deſcription of a Summer's Evening in theſe Words.

Confeſs'd from yonder ſlow extinguiſh'd Clouds,
All Æther ſoft'ning, ſober Evening takes
Her wonted Station in the middle Air;
A thouſand Shadows at her Beck. Firſt this

She ſends on Earth; then that of deeper Dye
Steals ſoft behind; and then a deeper ſtill,
In Circle following Circle, gathers round,
To cloſe the Face of Things. A freſher Gale
Begins to wave the Wood, and ſtir the Stream;
Sweeping with ſhadowy Guſt the Fields of Corn,
While the Quail clamours for his running Mate.
Wide o'er the thirſty Lawn as ſwells the Breeze,
A whit'ning Flow'r of vegetable Down
Amuſive floats.

Euphroſ. Theſe Deſcriptions are like the Poetry of Mr. *Thompſon*, where every Thing is extraordinary. —— As you have ſhewn me the *Morning*, *Noon*, and *Night* of the *longeſt Day* in the Orrery; let us now ſee the gradual Alterations which happen in regard thereto, while the Earth paſſes on to the Winter Seaſon.

Cleon. That ſhall be done, and is eaſy by ſetting the Machine in Motion. —— See the Earth moving on towards *Libra*, and at the ſame Time revolving about its Axis. —— And as it advances, you ſee the Circle bounding Light and Darkneſs (*b c*) continually approaching towards the Poles (N S) and that the Patch, repreſenting *London*, has its *diurnal Path* (*z o*) in each Rotation, conſtantly decreaſing, while the nocturnal One (*o x*) is increaſing as gradually, till at laſt they come to an Equality in *Libra* ♎.

Euphroſ. All this I ſee with great Pleaſure, —— and waiting a little, ſhall ſoon find the Earth in *Libra*: —— There ſeems now to be but a ſmall Difference between the diurnal and nocturnal Tracts of the Patch.

Cleon. Very little; —— it is now ſcarcely viſible. —— The Earth has juſt reached the Point, where I will cauſe it to move very ſlow, that you may better view the Appearances of the *diurnal Motion*.

Euphroſ. Very good; —— I ſee a perfect *Equality of Night and Day*, by Means of the Index and the Patch; *viz.* 12 Hours each. ——At the ſame Time, I obſerve the Reaſon of this to be, that the Sun is in the Equinoctial at this Time; and, conſequently, as all the Parts of the Earth have the diurnal Motion pa-

parallel thereto; and the Circle, bounding Light and Darkneſs, paſſes thro' the Poles; ſo half that Motion muſt be performed in the enlightened Part, and the other Half in the dark, for every Part between the Equonoctial and the Poles; and, therefore, Day and Night muſt needs be equal now over all the Earth.

Cleon. You have a very juſt Notion of the Matter; and can account for all the Phænomena of *Day and Night*, I believe, in any Situation of the Earth, or Seaſon of the Year. We will only, therefore, take a View of a Rotation or two of the Earth in the firſt Point of *Cancer*; that is, in the Midſt of the *Winter Seaſon.* —— Towards which you ſee the Earth advances with an accelerated Motion in her Orbit, and conſequently about her Axis. —— As *Autumn* paſſes off, you ſee *Winter* gradually coming on. —— The Days (with us) ſhorten, and the Nights increaſe; —— the N. Pole, by Degrees, declines from the Sun, while the S. Pole accedes nearer and nearer thereto.

Euphroſ. It is all very evident, indeed, *Cleonicus*; —— I ſee the enlightened Hemiſphere gradually remove from the N. Pole, and take in the Southern; and conſequently all the Parallels of N. Latitude have their diurnal Parts decreaſing, and the nocturnal increaſing; the Contrary of which I obſerve happening in the Southern Parallels. — But ſee, the Earth has reached the Beginning of *Cancer*, let it be ſtopped there a while, to obſerve more nicely the Phænomena of the diurnal Motion, in this dreary Seaſon.

Cleon. I will ſtop the annual Motion, and continue the diurnal One at ſuch a Rate, that you may make your Obſervations with Eaſe and Pleaſure. ——

Euphroſ. The firſt Thing I obſerve is, that the Circle of Illumination extends but a little farther than the Patch towards the North; and, therefore, the Path deſcribed by it in the enlightned Hemiſphere is but very ſmall in Compariſon of the Diſtance it goes thro' the dark One; but their Diſtances I can meaſure in Time, by bringing the Patch upon the Meridian, and placing the Hour Index at 12, as before. —— Thus, as the Earth revolves, I obſerve the Patch, or the City of *London*, enters the enlightened Hemiſphere a few Minutes after 8 in the Morning; which, therefore, is the Time of Sun-riſing to us, and goes out of it as much before 4 in the Afternoon; whence I ſee, that the ſhorteſt Day is not quite 8 Hours long, and conſequently not half the Length of the Night.

Cleon. You obſerve the Poſition of the Earth is juſt the Reverſe now to that which it had in midſummer Seaſon, or when the Earth was in the oppoſite Part of its Orbit; and, therefore, not only the Seaſons, but the Length of Days and Nights will be juſt the Reverſe of what they were then, and the very ſame which you may now perceive they are in the lower or ſouthern Parts of the Earth, at the ſame Diſtance from the Equinoctial as we are.

Euphroſ. I readily perceive it, and I ſhall demonſtrate it too by ſticking another Patch upon the ſame Meridian, and in the ſame Latitude with *London*, on the ſouthern Side. —— Now the revolving Earth brings the ſouthern Patch into the Sun-beams before the Hour Index points to 4 in the Morning, nor does it enter the darkened Hemiſphere till after the Hand has paſt the Hour of 8 in the Evening. —— I have now the Satisfaction to know by this Experiment how the Days and Nights come to be alternately equal in Winter and Summer, and alſo in the ſame Latitude on different Sides of the Equator. ——I farther ſee, that the Inequality of Day and Night ceaſes at a certain Limit, beyond which, on one Side, they are only deprived of Light or Day, and the other, they enjoy the Sun-beams conſtantly for the ſame Time. —— Thoſe who live under, and about the North Pole, ſeem now to have a tedious, horrid Gloom, while thoſe, who are in the ſouthern Pole, have the Sun bright above the Horizon, and enjoy an uninterrupted Day.—— How happy are we whom Providence has placed between two ſuch diſagreeable Extremes! For the Enjoyment even of Light itſelf, for a long Continuance, could not be pleaſant, and Darkneſs is what all Mankind are naturally apt to ſhun.

Cleon. Your Reflections in theſe Reſpects are very natural; but we are to conſider, at the ſame Time, how few of our Species have ſuch a Situation in Life. By our late Diſcoveries, it is pretty certain that there are few, or no Inhabitants of the Regions of the ſouthern Pole, it being in all thoſe Parts a conſtant frozen Ocean; and with Reſpect to the northern Polar Regions, the Continent of *Europe*, *Aſia*, and *America*, extend not far within them; and thoſe, whoſe Lot it is to inhabit thoſe dreary Regions, appear to be ſo wonderfully ſuited and adapted to them, that it is well known by Experience they prefer their native, gloomy Spot to any Part of our happier temperate Zone; nor are they ſo very much in the Dark perhaps as you may imagine, the Continuance of their Darkneſs being proportioned to their Diſtance from the Polar Circle, and greateſt of all at the Poles; but even there, the Moon affords them Light one half of the Time, and they enjoy a Twilight till the Sun is 18 Degrees below their Horizon; and it is very probable, that the Land does not extend ſo far as to admit of any Inhabitants within five Degrees and a half of the Pole, and to thoſe who are farther off than that, there can be no dark Night at all.

Euphroſ. I am glad to hear of any Thing that can contribute to ſolace thoſe unhappy Mortals in their joyleſs Situations; for I cannot help thinking they muſt be miſerable there; —— but I recollect the Kinds of Happineſs and Miſery are more Relative than Real; and I am the more convinced of it, when I conſider that even our Negroes quit their native Soil only by Force, and are ſo naturally fond of their ſable Complexion (at which I ſhudder almoſt as much as at Polar Darkneſs) that I remember I have ſomewhere read, they paint the Devil white, to repreſent him ſo much the more terrible to Mankind.

Cleon. Whoever contemplates the Nature of Things in the Manner you now do, will find it very eaſy to correct many of the common, but very unjuſt Notions of Nature and Providence, and will come at laſt to the Concluſion, that infinite Beneficence in the divine Being could never permit the Creation of any Species of ſenſible Beings, without a Poſſibility of enjoying a proper Degree of Felicity peculiar to their ſeveral Natures. — But leaving thoſe Digreſſions, we return to the remaining Seaſon of the Year in the Orrery, which the Earth enjoys in paſſing from the firſt Degree of *Cancer* to *Libra.*

Euphroſ. And, conſequently, while the Sun appears to go from *Capricorn* to *Aries.* —— But what are the particular Phænomena that we attend to during this Interval?

Cleon. Nothing in particular, more than to obſerve the natural Tranſition from the Winter to the Spring Seaſon; for when I give the Earth its annual Motion, and you ſee it proceeds in its Tour, you will plainly obſerve, that by Reaſon of the parallel

Poſition of the Axis the northern Pole will gradually return and reſtore the Regions now in Darkneſs to the enlivening Influence of the Sun. —— See it now moves on.

Euphroſ. I obſerve the Particulars you mention begin to appear in a very natural Manner. The Archs of the Parallel, that meaſure the Day, now gradually increaſe, and thoſe which ſhew the Night of Courſe decreaſe in all the northern Latitudes. The Coldneſs of the Seaſon, one would think, ſhould now alſo abate, and every Day after the 21ſt of *December*, one might expect, ſhould be warmer and warmer; but this does not quite tally with Nature; for you muſt have obſerved, *Cleonicus*, that *January* and *February* are oftentimes found to be the two coldeſt Months in the Year. Pray, how am I to underſtand the Reaſon of that?

Cleon. In a Manner as I heretofore hinted in relation to the Summer Heat; I then remarked to you, that the Summer's Heat was not greateſt at Midſummer; and for the ſame Reaſon you are not to expect the Intenſity of Cold by the Middle of Winter. The Cauſes of Cold continue much longer, *viz.* the different Length of Days and Nights, the Obliquity of the Sun's Rays, *&c.* ſtill continue to produce Degrees of Cold, which, added to all that went before, the Agregate, or Sum of All, will produce the greateſt Degree of Cold in the Months you mention.

Euphroſ. I apprehend you clearly; ——— but ſee, the Earth has juſt now carried us thro' thoſe Months; I am pleaſed to ſee the freezing Tropic left ſo far behind in the artificial Year, and the Return of the vernal Equinox ſo near at Hand. Nature ſeems now renewed even in the Orrery, and ſolar Beams diffuſe themſelves almoſt from Pole to Pole once more. —— *London*, in its vicegerent Patch, now enjoys near equal Length of Days and Nights. ——— The Sun from the Earth appears in *Virgo*, and the Index ſhews him every Day advancing about one Degree forward. —— Scarce any Difference now appears in the Length of the Day and Night. ——— The Circle of Illumination paſſes thro' both the Poles. ——— And now the Year is finiſhed in the Orrery; for the Index points to the 20th of *March*.

Cleon. The Machine has now done you all the good Offices in its Power for the preſent; you have thereby ſeen in a ſhort Time repreſented all the Phænomena of the Heavens; and what gives me a peculiar Pleaſure, even beyond that of informing your Mind, is to find your Taſte for Philoſophy ſo true and juſt, that thro' ſo long a Series of Speculations on theſe Subjects they ſeem ſtill entertaining and agreeable to you. ——— For to ſay that now, which at firſt I was not willing you ſhould ſuſpect, I was much in Doubt (tho' you expreſſed ſo great a Deſire of being inſtructed in the *Celeſtial Science)* whether or no your Patience would hold out ſo long on one continued Subject. ——

Euphroſ. So long, do you ſay, *Cleonicus!* On my Word, were you not my Brother, I ſhould ſcarce forbear being affronted by ſuch an Expreſſion. ——— Patience for Inſtructions and Pleaſures of this Kind! ——Tired with contemplating the Powers and Works of Nature! ——— What did you take me to be, *Cleonicus*, once to think of my palling on thoſe divine Subjects? ——— No, I remember too well what *Shakeſpear* ſays of the Wretch who cannot reliſh Muſic, " *He is fit for Rapines, Murders, &c.*" —— How then muſt that unnatural Soul be characteriſed, that cannot always be delighted with the Muſic of the Spheres! with the Beauty and Harmony of the divine celeſtial Frame of Nature! That ſublime, viſual Muſic, thus repreſented by the ſame celebrated Poet. ———

Beauty is Muſic too, tho' in Diſguiſe,
Too fine to touch the Ear, it ſtrikes the Eyes,
And thro' them to the Soul the ſilent Stroke conveys,
'Tis Muſic heav'nly, ſuch as in the Sphere,
We only can admire, but cannot hear.

——— Beſides, do not the moſt judicious Divines and Philoſophers tell us, that an infinite Scene of the Operations of divine Power and Wiſdom will open itſelf gradually to our View in the future heavenly State, and that the Employment of Time to endleſs Ages will conſiſt in an uninterrupted Intuition and Contemplation of the ſame? If ſo, how prepoſterous muſt it be, and contrary to the Character of a divine and rational Nature in us, to ſuppoſe it but even poſſible for a Perſon to meditate with Indifference on theſe Subjects, much leſs to think them tedious, tho' our whole ſhort Life were conſtantly employed therein.

Cleon. What you ſay is certainly true, my *Euphroſyne*; but withal it muſt be obſerved, that in this imperfect preſent State, the Mind of Man is naturally apt to be fatigued with any Kind of conſtant Study; and we muſt always propoſe theſe Matters as Subjects rather of Amuſement than the Buſineſs of Life; we are not here to know what perfect Happineſs is; nor can we enjoy it in any Degree, unleſs under particular Reſtrictions, and as the Reſult of an agreeable Mixture and Variety of Incidents. Therefore we ſhall, for the preſent, leave thoſe Fields of Æther, where Suns refulgent ſhine, and Planets and Comets go their ample and ſolemn Rounds; and deſcend to the nether Regions of *Air*, a ſtupendous Inſtance of divine Omnipotence; and whoſe wonderful Properties are highly worthy your Notice and Attention. There we ſhall ſee how every Part is duly ordered to render it as uſeful as it is neceſſary. —— We ſhall find it the natural Means of Life to Animals and Vegetables. ——— The *Medium* for propagating Sounds. ——— The Method that Nature has taken to render all Objects viſible unto us, by making it the general Receptacle of Light. ——— The *Medium* of Flying, and the Habitation of numberleſs Animals of the winged Kind. — That Medium which alone affords the proper *Pabulum* of Fire and Flame. ——— The Element and Eſſence itſelf of Winds, Storms, and Tempeſts. —— The Medium in which alone Vapours and Exhalations can have any Exiſtence. ——— And laſtly, The natural Means and Cauſe of all Kinds of Meteors, watery or fiery, ſuch as Fogs, Clouds, Rain, Snow, Hail, Thunder, Lightening, the *Aurora Borealis*, *&c.*

The Young GENTLEMAN and LADY'S PHILOSOPHY.

PART III.

PNEUMATICS:

OR,

The Nature and Properties of the AIR explained.

The Structure and Uſe of the AIR-PUMP, and other Inſtruments.

AND

The Doctrine of *Wind*, *Sound*, *Meteors*, &c.

DIALOGUE I.

On the Nature, Form, and Magnitude of the ATMOSPHERE, *or Body of* AIR.

Euphroſyne.

WELL, you are reſolved to make a Philoſopher of me, I find; you have brought me into a new Field of Enquiry, and a very *airy One* too, *Cleonicus*.

Cleon. Indeed it is, Siſter, literally ſo; you are now to explore the Regions of the *Air*, and dwell, for ſome Time, amongſt the *Clouds*.

Euphroſ. That is, I ſuppoſe, in plain *Engliſh*, I muſt now inform myſelf of the Nature of the Air, and its Uſe in the Syſtem of the World.——To this I ſhall addreſs myſelf with great Readineſs and Spirit; eſpecially as I know of nothing in Nature that I have heard more about, and am leſs acquainted with, than this extraordinary unſeen Something, you call Air. — Pray, what Definition do you give to this Subject?

Cleon. The Air is defined to be *a fine, inviſible, heavy, elaſtic, compreſſible Fluid, of a different Denſity, environing the Earth on every Side to an indefinite Height.*

Euphroſ. So many Characters entering into a bare Definition of it ſeem to make it an important Subject; pray, what are its general Qualities and Uſes?

Cleon. I will tell you in a few Words.

The principal Property of the Air is its Weight or Gravity; for tho' a ſmall Portion of it be light, yet, conſidering the great Height to which this Body of Air extends, the Weight of any Column of Air upon a given Surface muſt be very great. For by ſome Experiments that you will ſee hereafter, you will be eaſily convinced, that the Preſſure of a Column of Air upon a Square Inch only is equal to *fifteen Pounds Weight.*

Euphroſ. Such an Experiment I ſhall gladly ſee; for, when you talk of ſuch a Weight of the Air, I ſcarce know how to underſtand you, as I never yet experienced any Weight or Preſſure in the Air at all; nor ſhould I have thought of any ſuch Thing, had it not been for what I have heard you and other Gentlemen ſpeak of, when you have been talking of the *Air-Pump.*

Cleon. Moſt People ſay, and think as you do; they know little of this Matter for Want of the proper Means of being acquainted with it, and never fail of being wonderfully ſurprized, when they are told the Preſſure of the Air upon the Surface of their Bodies amounts in general to at leaſt 13 *Ton Weight.*

Euphroſ. I don't wonder at their being ſurprized at ſuch a ſtrange Doctrine as this; for which Way is it poſſible a Perſon ſhould ſuſtain ſo prodigious a Preſſure, and yet, at the ſame Time, be entirely inſenſible of it?

Cleon. This you will be ſatisfied of when you conſider, that the Air is a fluid Body, and you will be taught hereafter to underſtand, that all Fluids preſs with an equal Force every Way, as well upwards as downwards, Side-ways, and in all Directions you can conceive, and then, allowing that every ſquare Inch upon a Man's Body ſuſtains a Preſſure of 15 Pounds, the

Preſſure upon the whole Surface will amount at leaſt to 13,320 Pounds upon the Surface of a middle Size Man (as it is found by Computation) which is very nearly 14 Ton Weight.

Euphroſ. This is a Subject I cannot at preſent diſpute with you; but if this be the Caſe, what I moſt wonder at, at preſent, is, how it comes to paſs, that I am ſo far from apprehending any ſuch great Weight from the uſual Effects in all other Caſes, that in reality I find nothing at all of it.

Cleon. The Reaſon of this ſtrange Phænomenon, if I may ſo call it, is this, that our Bodies, as well as all others, are filled with Air throughout, and the Spring of this internal Air is a Force juſt equal to the Preſſure of the Air without, and when two Forces equal to each other act in contrary Directions, they intirely deſtroy each others Effects; and any Body, being preſſed with great Force from the ambient Air, is really in the ſame Caſe as if it was affected by no Preſſure of the Air at all; of this too you will be made thoroughly ſenſible by Experiment.

Euphroſ. The Knowlege of ſuch myſterious Things will be a very agreeable Acquiſition; but pray, by the Way, tell me how the Air, a Subſtance which I can neither ſee nor feel, can be ſo heavy a Body.

Cleon. The Weight of the Air ariſes from the ſame common Cauſe as the Weight of any other Body does, *viz.* from that Power, or Force in Nature which is uſually called *Attraction*, or *Gravitation*. This Power, as Sir *Iſaac Newton* tells us, equally affects all the Parts of Matter, and produces in them a Tendency towards each other; and this Tendency or Force is that which we call the *Weight* of any Body. Thus, what we commonly call the Weight of a Stone is only its Endeavour to fall, or approach towards the Body of the Earth, and thus every Particle of Air endeavours equally to fall towards the ſame Surface of the Earth, and therefore the Sum of all thoſe Forces, in all the Particles, make a conſiderable *Sum Total of Weight*, or *Preſſure* in the Air.

Euphroſ. If then the Particles of Air are like ſo many Stones, why then do they not fall like the Stones, and all abide upon the Surface of the Earth? Whereas, on the contrary, you tell me, that they fill a very great Space in the circumambient Regions.

Cleon. In order to anſwer this Queſtion, which you have very properly propoſed, you muſt be acquainted with one other Power in Nature, by which the Parts of Matter, when they are at a certain very ſmall Diſtance from each other, are made to *repel*, or *fly* from each other; and this is what the Philoſophers uſually call the *repulſive Force*, or *Elaſticity* in the Parts of Matter. The Force which I before mentioned under the Title of Gravitation, is, with Reſpect to the ſmall Particles of Matter, called the Attraction of Coheſion, or it is that divine Power in Nature which ſo affects the Parts of Matter, that while they are in Contact, or can touch each other, they are by this Means made firmly to cohere or abide together, and according to the different Figures of the Parts of Matter, this Power will produce a greater or leſſer Degree of the Force of Coheſion, which is the general Cauſe of all Degrees of Hardneſs or Softneſs in Bodies, and what we uſually call Fixity and Fluidity. But more of this Subject hereafter. The Parts of Matter, as I ſaid before, when they are once beyond the Sphere of this attracting Force, are found to be ſtrongly actuated by the repelling Force; and this is the Caſe of Air, the Parts of which do conſtantly repel each other, and therefore thoſe which are next to the Surface of the Earth will prevent the other Particles above them from coming ſo near to it by their repulſive Force or *Elaſticity*; and this is the *ſecond great Property of the Air.*

Euphroſ. By this ſecond Property of the Air, which you call Elaſticity, I ſuppoſe, if I underſtand you right, the Parts of Air are kept a Diſtance from each other; but ſtill it is not clear to me how this can be the Caſe; becauſe of the great Weight of the Air, which one would think ſhould precipitate thoſe Particles at once down to the Surface of the Earth. Pray, why is not this the Caſe?

Cleon. Becauſe the Elaſticity of the Air is a Force ſuperior to that of Gravitation; or in other Words, the repelling Force in the Parts of Air which keeps them aſunder is greater than the attracting Force between the Earth and thoſe Particles by which they tend toward the Earth, and at a proper Time you will underſtand, that this repulſive Force is the ſtrongeſt Power in Nature; that theſe two Principles *an attracting* and *repelling Force* are the efficient natural Cauſes of all the Appearances in Nature; and that the Properties, Qualities and Effects of all Bodies entirely reſult from them.

Euphroſ. But if the Parts of Air do repel each other, as you ſay, with ſo great a Force, how comes it to paſs that we have any Air at all? Why does not this elaſtic Force drive all the Particles of Air quite away? What do you find confines them hovering round this Ball of Earth?

Cleon. Your Queſtion is *à propos*, Siſter; but ſtill you are to conſider, that the Power of Gravity is very conſiderable, tho' not entirely equal to the Elaſticity of Air, and prevents this latter Force from having its full Effect. Were the Power of Gravity for a Moment to be ſuſpended from Matter, and the Power of Elaſticity to remain, the Atmoſphere, or Body of Air, like a Parcel of Gun-powder ſet on Fire, would inſtantly be diſſipated thro' the infinite Regions of Space; but by Means of Gravity, by far the greateſt Part is detained near the Surface of the Earth, and the Diſtance between the Particles only leſſened; and more ſo, as the Particles of Air are nearer to the Earth. For at a greater Diſtance they are leſs affected by the Power of Gravity, and are leſs heavy, and therefore the Effect of Elaſticity will be greater, or keep the Parts of Air at a greater Diſtance from each other; and thus it will be eaſy to underſtand, that the farther you go from the Surface of the Earth, the greater the Diſtance will be found between the Particles of Air; and the nearer the Surface of the Earth, the leſs thoſe Diſtances; and this leſſer or greater Diſtance between the Parts of the Air is uſually called its *Denſity*, or *Rarity*; for the leſs the Diſtance is, the greater will be the Number of Particles in the ſame Space, and the Air is, in ſuch a Caſe, ſaid to be *more denſe:* On the Contrary, the greater the Diſtance between the Particles, and the Air, in ſuch a Caſe, is ſaid to be *more rare*; from whence it will appear, that the Denſity of the Air in any Part will be always in Proportion to the Weight of that above, and conſequently, greateſt of all at the Surface of the Earth: Likewiſe, from theſe Principles it will follow, that the Weight of the Air and its elaſtic Force are always equal to each other, and therefore produce an univerſal *Equilibrium* among the Particles of Air in every Part of the Atmoſphere.

Euphroſ. According to this Account of the Denſity and Rarity of the Air, what Idea can I form of the Height of it? For, if the leſs the Air be compreſſed the more it is expanded, and the farther you go from the Surface of the Earth, the leſs that compreſſive Force will be, where am I to conceive the Bounds or Limits of the Atmoſphere to be?

Cleon. No where at all; for the Parts of Air in the upper Regions will be expanded to Infinity, 'till at Length we may very properly underſtand, that the Atmoſpheres of every Body in each Syſtem, and of all the Syſtems in the Univerſe, meet with each other in the diſtant Spaces between, and mixing together, conſtitute that fine *æthereal Medium* which fills the Abyſs of Space.

Euphroſ. This is a wonderful Doctrine; but it certainly muſt be as you ſay from the Nature of Things, as you have now explained it. Therefore, I apprehend it will be in vain to enquire about the Height of the Atmoſphere, or Body of the Air.

Cleon. All that can be ſaid in reſpect to the Height of the Air, is this, that the Denſity of it, at the Height of about 45 Miles, is but juſt ſufficient to inflect, or bend a Ray of Light out of its right-line Courſe, which is the leaſt Effect it can produce, and therefore all beyond that Height muſt be eſteemed an unreſiſting *Æther.*

Euphroſ. As the Air is ſuch a very extraordinary Subſtance, and poſſeſſed of ſuch wonderful Qualities, how comes it to paſs, that we can ſee nothing of it? For if it was not ſenſible otherways, I ſhould know of no ſuch Thing by the *Sight.*

Cleon. Why even in this Reſpect you may not be free from Miſtakes. The Air in ſome Caſes, tho' very rarely, is ſubject to the Sight, or may be perceived by the Eye; but as this ſeldom happens, we look upon the Air in general as altogether inviſible; and it is neceſſary it ſhould be ſo; for, as it is the Medium thro' which we ſee Objects, if the Parts of Air were in the leaſt Degree perceptible, it would render the View of thoſe Objects leſs perfect and diſtinct; as is well known by the Experiment of viewing Objects thro' a Teleſcope, which magnifies to a very great Degree; as it ſhews the Body of Air, ſo it renders the View of other Objects more confuſed, and indiſtinct, which plainly convinces us of the Wiſdom of the divine Architect in rightly diſpoſing this Part of the Conſtitution of the World.

Euphroſ. But you was juſt now mentioning ſome particular Caſe in which the Air becomes viſible; pray, what is that? For I ſhall have a great Inclination to have a View of ſo rare a Spectacle.

Cleon. That you may do under the following Circumſtances: In a very hot Summer's Day, take a Walk to ſome open Parts of the Country, and place yourſelf upon an Eminence or riſing Ground, in a Situation nearly facing the Sun; then, if there be any gentle Wind, or Motion of the Air, it will be ſhewn by Reflection of Light from the Body of the Air in the Vale below, and you will as perfectly ſee the Undulations or Waves of Air, almoſt, as you may thoſe of Water agitated by a gentle Wind.

Euphroſ. This will afford me a particular Satisfaction, and I ſhall take the firſt Opportunity to gratify myſelf in this Reſpect; and then I ſhall know by Experiment, what I otherwiſe find, *that Wind is only Air in Motion.*

Cleon. It is very true, Siſter: You have hit off the whole Philoſophy of Wind at once. For ſuppoſing the Air was perfectly quieſcent or ſtagnant, there would be no Wind at all; but as the Degrees of Motion, or Agitation in the Body of Air are greater or leſſer; ſo we find ſtronger or weaker Winds ariſe; and as the Motion of the Air is this Way or that, ſo we uſually ſay, the Wind blows from one Quarter or the Other, or from one Point of the Compaſs or another.

Euphroſ. Pray, what are the general Cauſes of Wind, or this Motion of the Air that you ſpeak of?

Cleon. The particular Cauſes of Wind are many; but one general Cauſe is the Inequality of Heat and Cold in different Parts of the Atmoſphere; but this will prove the entire Subject of a future Converſation. And as it will be proper, not only to tell you, that the Air has ſuch and ſuch Qualities, but to convince you by Experiments, that they do really exiſt, I ſhall make ſome Preparation for that Purpoſe againſt the next Opportunity; and ſo for the preſent, Adieu.

DIALOGUE II.

Of EXPERIMENTS *to ſhew the natural Production of* AIR.

Euphroſyne.

SO! You have ſpread the Table, I ſee, for my Entertainment. I can aſſure you, to feaſt my Mind on theſe Things affords me as much greater Pleaſure than the common Productions of a Cook's-ſhop can afford the Palate, as the Subject of the fineſt Parts of Philoſophy can be ſuppoſed to exceed all the Merits of the Art of *Paſtry.*———I make this Sort of Compariſon (which I know you will allow to be juſt) becauſe I was the other Day in Company, where a certain Perſon, having juſt before diſplayed his Talent in deſcanting upon what was *fine Eating and Drinking*, and how happy it was to have a critical Taſte to diſtinguiſh the Delicacies of a *Haut Goût*, and the genuine Flavours of *Burgundy* and *Champaign*, which took up the beſt Part of Dinner-time, and an Hour after; at length, he was pleaſed to direct his Diſcourſe to me, and with an Air of Pleaſantry to tell me, that he heard I was intent on the Studies of Philoſophy, and that I was already become a very conſiderable Adept in it; that I had long been converſing with the Stars, and after much more of ſuch Kind of complaiſant Raillery, he added (by Virtue of a Bumper of *French* Port) that it had quite opened a new Scene to his View; that he had always looked on the Fair-Sex till now in a different Light; and that their higheſt Pretenſions were to no more Skill than the *Oeconomy of a Kitchen*; and the pretty Dexterity of making *Puddings and Pies* ——It will not be worth while to inſiſt on what farther paſſed between us; but though I was in ſome Meaſure affected by ſuch a faſhionable Piece of Ridicule; yet I conſidered, that Philoſophy was too amiable a Science to be bantered out of my Regard for it, ſetting aſide the natural Propenſity that I always had to the Study of it; therefore let me not interrupt you any longer, but proceed to your Experiments; for I muſt ſtill long to be acquainted with the Nature of this neceſſary Element, and learn how, and by what Means it is produced.

Cleon. It is Pity that any, even of our Sex, ſhould ſo far betray their Want of Prudence as to ridicule a philoſophical Diſpoſition in Others, only for Want of a Taſte for the Science themſelves. I muſt allow this is but too often the Caſe; I only wiſh one Thing for the Honour of our Sex, that many of them had but half the natural Genius and Capacity of Improvement in natural and mathematical Sciences as many of the Ladies are poſſeſſed of:———But to the Purpoſe; you remember, I told you, when we laſt converſed together, that the Parts of Matter by *Attraction and Repulſion* were put into Motion, and that whenever by this Means they could be ſeparated beyond the Sphere of Attraction, they commenced a repelling State, and then, as they were at a greater Diſtance from each other than before, they muſt become very light, and ariſe into the Body of the Air in Forms of Vapours and Exhalations of various Kinds. Thoſe elaſtic Particles that riſe viſible to the Sight are what we uſually call Vapours, or Steam; ſuch as we commonly ſee riſe from the Surface of heated Water and other moiſt Subſtances.

Euphroſ. This I am convinced of every Day by my Tea-kettle, in which I have often wondered at that Violence and Impetuoſity with which it iſſues from the Spout; and I now begin to ſee ſomewhat of the Reaſon and Cauſe thereof, *viz.* that it ariſes from the Elaſticity of its Parts, which by Experience I know is greatly augmented by Heat; but can you tell the particular Manner in which that is effected?

Cleon. As I ſhall ſhew hereafter, that all Heat conſiſts in the great Velocity or ſwift Motion of the Parts of Matter, and the Velocity of the Particles of Light is the greateſt of any, which we know of in Nature; ſo we find, that thoſe Particles by their Action always produce the Senſation of Warmth or Heat, and being plentifully imbibed by all Kinds of Bodies, theſe active Particles are conſtantly employed to ſeparate the Parts of Bodies, and by this Means to produce the natural Exhalations or Steams from every heated Liquor. Theſe ſenſible Vapours riſe into the Air, and make a Part of the Atmoſphere; for the Air is conſtantly filled with Particles of Moiſture, which by Heat are ſo far attenuated as ſeldom to be ſenſible to the Sight.

Euphroſ. Then what you now ſay, I preſume, is the Reaſon why in the Morning or Evening, when the Air is cool, we ſee the Vapours ariſe from the Earth into the Air, and alſo in a very cold Winter's Day, our very Breath becomes viſible to the Eye, as it then wants a ſufficient Degree of Heat to rarify the Particles, and make them eſcape the Sight.

Cleon. You underſtand this Matter very well; and in the ſame Manner you are to imagine, that ſolid Bodies will have their ſuperficial Parts ſeparated by the Action of Heat, and theſe Particles ſo ſeparated will be affected with a repulſive Force; which repulſive Force will cauſe them to aſcend into the Body of Air, and become a Part of the Atmoſphere itſelf. Theſe Particles ariſing from ſolid Bodies are always too fine to be viſible to the Eye, and therefore it is, that we rarely know, or even think of any ſuch Thing, and we find by Experience, that all Bodies loſe their Parts in Proportion as they are more actuated by the Power or Particles of Heat; and when the Degree of Heat is very intenſe, there are but few Bodies, whoſe Parts are ſo fixed, or cohere ſo firmly, as not to be ſeparated by their Action; and the Experiment which I ſhall now ſhew you, will be a ſufficient Confirmation of this Truth.

Euphroſ. Pray, to what Purpoſe is this fine Pair of Scales and theſe ſeveral Slips of Paper, which I ſee, and the Wax-candle? I ſuppoſe, they are all to be concerned in the Experiment you mention.

Cleon. 'Tis true they are: The Candle is to ſhew you the great Power of Heat, or Fire, upon the Parts of thoſe Pieces of Paper while they are burning, and they are all firſt weighed very nicely by thoſe Scales. The Quantity which I have here provided weighs juſt 100 Grains, as you ſee by placing the ſeveral Slips in one Scale, and the Grain-weights in the other.

Euphroſ. I ſee they juſt equipoize each other; but how am I to know what Parts are converted into Air in burning?

Cleon. By weighing the Aſhes which remain; for theſe we can collect, and place in the Scale without the Loſs of a ſingle Particle.———Thus, I take the firſt, and put it to the Flame of the Candle; it takes fire, and regularly burns down to my Finger; the Parts, you ſee, all fly off in Flame, except that fixed and earthy Part which is called the *Calx*, and which I now place in the Scale.———Then I take the Second, and burn it accordingly, and put the remaining *Calx* to the other in the Scale:——

And in this Manner I proceed with them all: ——— And now, my *Euphroſyne*, you ſee all their *Aſhes* in the Scale, and you will obſerve how light they are; you take out the former Weight of the Paper before it was burnt, and put in Others to make an Equilibrium with the Aſhes, and you find, that 6 Grains is ſufficient for that Purpoſe.

Euphroſ. I ſee that is the Caſe: A 100 Grain's Weight of Paper is now reduced to ſix only; I can eaſily underſtand from thence, that 94 Parts of a 100 of this Paper has been driven into the Air by the Action of Fire, and ſo much of the Paper, I preſume I may ſay in the philoſophical Stile, is *converted* into Air.

Cleon. If my Definition of Air be allowed, ſo much of the Paper is moſt certainly *transformed* into Air. The Parts are gone, we are ſure, by Deficiency of their Weight. They could not be annihilated; they could not riſe, and fly away without a repelling Force to carry them off, and they are too fine to be perceived by the Eye, after they are got beyond the ſmall Extent of the Flame. Thus, the Candle itſelf by Degrees is waſted, and at length is *tranſmuted* from a Subſtance of heavy, co-heſive, palpable Wax, to that of a light, elaſtic, and impalpable Body of Air.

Euphroſ. By this Example I ſee what wonderful Changes are made in the Nature of Things by the Action of Heat and Fire; and one Thing I cannot help taking Notice of is, *viz.* that all thoſe Parts of Bodies which in this Way become Air muſt firſt put on the Appearance of Fire itſelf, or paſs thro' the intermediate State of Flame; ſo that, properly ſpeaking, the ſame Body was one Moment *Paper*, the 2d Moment *Fire*, and a 3d *Air*; all which appear to be very different States for the ſame Sort of Matter to ſubſiſt in, in ſo very ſhort a Time.

Cleon. And yet, as wonderful as ſuch Operations of Nature muſt appear, when rightly conſidered, we ſee how little Effect they have on the unthinking Part of Mankind. They ſee their Wood and Coal every Day in this Manner converted into Air, without entertaining any Thought or Reflection on the Nature of the Thing, or being any otherwiſe affected than by its Heat.

Euphroſ. You cannot expect that People ſhould go to philoſophiſing on every Fire they want to warm themſelves by. If they are warmed, and the Pot boils, no Matter what becomes of the Wood, when it is burnt.———But what mean theſe other Parts of your Apparatus,———The Phial——the Chalk——the Tube———the Quick ſilver, which I here ſee in a Kind of promiſing Situation?

Cleon. Theſe are all deſtined for the Illuſtration of this important Point, the *Production of Air*. The firſt of theſe is the Glaſs-tube, which you obſerve with a Braſs Cap at the End, and a ſmall Hole in it; this Tube I ſhall fill with Water, and a ſmall Quantity of *Aqua Fortis* to make it acid; then this Piece of Chalk being put into the Mixture, a Fermentation will enſue, by which the Particles of Chalk will be ſeparated, and turned into Air; for Fermentation is another grand Operation in Nature, by which the Parts of Bodies undergo the greateſt Variety of Tranſmutations, and by which many of their Parts are conſtantly changed into Air. But, that you may ſee the Effect of this Experiment in the moſt convincing Manner, I ſhall firſt fill the Tube with Water; and then, tho' I place my Thumb on the Top of it, you obſerve no Water runs through the Hole at the Bottom.

Euphroſ. I do, but ſince there is a Hole open, pray, why does not the Water deſcend by its Weight?

Cleon. Becauſe the Air, being a fluid Body, preſſes upwards as well as downwards, and the Preſſure upwards againſt the Water in that Hole is much greater than the Preſſure downwards, and therefore will prevent its running out.———But ſee, I take my Thumb away, and then the Water deſcends in a Stream thro' the Hole.———I place my Thumb on again, and it ſtops.——I remove my Thumb, and the Water runs out.

Euphroſ. There is ſomething odd in this Appearance, and yet, I believe, I ſee the Reaſon of it; for when the Tube is open on the Top, and the Weight of the Air lies upon the Water, and the Weight of both together downwards being greater than the Preſſure of the Air upwards, muſt neceſſarily make the Water run out; and of Courſe it muſt ſtop again, when the Tube is cloſed on the Top.

Cleon. I ſee nothing will eſcape your Sagacity; and now you are prepared to ſee the Effect of Fermentation.———You ſee, I fill the Tube with the acid Mixture.———I put in the Piece of Chalk———and immediately I put in the Cork, ſo that you now ſee the whole Tube filled with the Fluid only, without any Air at the Top.———But behold! Numberleſs Bubbles of Air ariſe from the Chalk in a conſtant Succeſſion to the Top of the Fluid: The Conſequence of this is, that the Fluid muſt be preſſed by this new Air, and when its Spring becomes greater than that of the common Air on the Outſide, it will drive the Fluid out of the Tube.———Thus you ſee it keeps continually dropping from the Hole.

Euphroſ. 'Tis with great Pleaſure I obſerve what you ſay—What prodigious Quantities of Air do I ſee conſtantly ariſing from the Chalk!———It is a perfect Evaporation of Air.———The longer it continues the greater is the Fermentation, and the faſter the Water drops from the Tube——It has now expelled more than one Half, and will ſoon drive the Whole of it out.—But, pray, *Cleonicus*, whence comes this Air from the Chalk? It is not that which is contained in the Pores of the Chalk?

Cleon. No, my *Euphroſyne*, you muſt take Care of the common Miſtake. Moſt People, as well as you, are apt to think, that it is owing to the Dilatation of natural Air contained in the Pores of Chalk; but they are greatly miſtaken; for ſuch Air cannot be dilated, or made to poſſeſs a larger Space than what it naturally does, unleſs it be by Heat, or taking off the Weight of the circumambient Air; for the Fermentation produces no Heat in the Chalk, and therefore the Air, contained in the Pores, cannot be diſlodged upon that Account. Nor is the Preſſure of the Air leſſened upon the Chalk, but really increaſed by the additional Weight of Water; therefore, it is impoſſible upon either of theſe Accounts, or any other, to conceive, that this Air, which we ſee ariſe from the Chalk, fill the Tube, and drive out the Water, ſhould any how proceed from the Air in the Pores of the Chalk.

Euphroſ. You have ſaid enough to convince me that it cannot; and if it be not from that Air, it muſt be from the Chalk itſelf of Courſe; and I ſuppoſe, by what you have hitherto ſhewn me, I may venture to ſay, that the very Particles of the Chalk itſelf are changed into Air by Fermentation.

Cleon. That is the very Caſe: The Chalk becomes Air, or a Subſtance altogether inviſible to the Eye. It has an elaſtic

Force, and that ſuperior to the Elaſticity of common Air, as is demonſtrable by forcing the Water out of the Tube, which was at firſt kept in by the common Spring of the Air.

Euphroſ. But what means this Tube with a Bladder tied on to the End?

Cleon. That is for an Experiment to the ſame Purpoſe.—— You ſee here this Phial, into which I put the ſame acid Mixture and Chalk———and the ſame Effect you now obſerve enſues.———In the Braſs Cap on the Top of the Phial, I ſcrew on the Glaſs Tube with the empty Bladder on its End.——— And now you readily perceive, that the new generated Air ſhews itſelf by entering the Bladder, and expanding it by Degrees.

Euphroſ. A curious Phænomenon this!———The Bladder begins gradually to unfold, and to increaſe in its Bulk from the increaſing Quantity of Air ariſing from the Chalk. I apprehend, if we could wait to ſee this Experiment in its utmoſt Extent, the Bladder would be not only filled with Air, but at length would burſt by the Force of its Spring.

Cleon. It certainly would, in the ſame Manner as it might by injecting the common Air with a Syringe; and therefore the Appearance and the Effects of this new generated Air being exactly the ſame with the common Air, there is no room to doubt, but that the Particles of Bodies are converted into the common Air that we breathe. But we have ſtill other Experiments, which I ſhall ſhew you for the Sake of Variety, that will as evidently prove the Fact.

Euphroſ. I am fully ſatisfied and convinced of the Truth of this important Affair, but ſhall be glad to ſee it further illuſtrated by a Diverſity of Experiments. Pray, what is your next?

Cleon. From this Phial, I ſcrew off the Tube with the Bladder, and to the acid Mixture I pour in a Quantity of Quick-ſilver; then I take this Glaſs-Tube, 30 Inches long, and ſcrew into the Phial with the lower Part deſcending a ſmall Depth into the Mercury.———The Chalk now (as in the former Experiment) you ſee, yields a large Quantity of Air, which, as it cannot get out of the Phial, muſt preſs upon the Surface of the Quick-ſilver, and raiſe it up in the Tube——See, it begins to aſcend.——

Euphroſ. It evidently riſes, and a delightful Sight it affords me. ——— It keeps gradually riſing, which ſhews the conſtant increaſed Spring of the Air in the Phial, ariſing from the Chalk. —— But, pray, *Cleonicus*, what would be the Caſe if this Experiment was to be tried for a long Time? To what Height would it raiſe the *Mercury* in the Tube?

Cleon. The Height of the *Mercury* would continue encreaſing, 'till ſuch Time as the Spring of the Air in the Phial (which is always equal to the Weight of the *Mercury* in the Tube) becomes ſo great, as to burſt the Phial; and then, of courſe, the Experiment will be over.

Euphroſ. Why, you almoſt begin to make me afraid; for I ſee the *Mercury* is now high in the Tube. —— Pray, unſcrew the Tube, and let the Air out, leſt I ſhould ſee the Experiment concluded in the Manner you mention, which I would not chuſe by any Means to do.

Cleon. I don't wonder, if your Timidity exceeds your Curioſity. No Body would care to be preſent at the burſting of a Glaſs. ——— But now obſerve, as I gently turn the Screw back, the Air goes out by ſmall Degrees, and you ſee the Quickſilver ſubſiding in the Tube, which is no unpleaſant Part of this Experiment.

Euphroſ. Every Part of this Experiment is really very curious, and I am convinced of the Truth of that Doctrine, which to me, at firſt, appeared not ſo very plain and demonſtrable, and therefore ſhould put you to no farther Trouble upon this Head, were it not, that you have yet one Experiment ſtill remaining; which, I fancy, muſt be ſomewhat curious, by the Manner of it.

Cleon. 'Tis true, this is the *Experimentum Crucis*, as the Philoſophers call it, or one perfectly deciſive. I have before obſerved to you, that the Weight of any Body is always proportioned to the Number of Particles, or Quantity of Matter in it; from whence it follows, that, if the Quantity of Matter be diminiſhed, the Weight of that Body will be leſſened in the ſame Proportion; therefore, to ſhew that it is the real Subſtance, or common Matter of the Chalk, which is changed into Air by Fermentation, I have contrived the following Experiment.—— I put into one Scale of the Balance, a ſmall, cylindrical, glaſs

Cup, with a proper Quantity of the acid Mixture in it, ——— over which I place a Paper-cover: ——— On this Paper I place a Piece of Chalk, and then balance the Whole by Weights, put into the other Scale:———Laſtly, I gently ſlip the Chalk into the Mixture under the Paper-cover, which prevents any of the Fluid flying off from the Cup in the Ebullition. ——— And now obſerve the Effect: As the Fermentation continues, the Particles of the Chalk change into Air, and fly away, and you obſerve that Scale is ſenſibly become lighter, and preponderated by the other. This plainly ſhews, that the Subſtance of the Chalk is conſtantly diminiſhing by the Diminution of its Weight; and you may ſee at any Time how much of the Weight is deficient, by putting Grain-weights into the ſame Scale to reſtore the *Equilibrium*.

Euphroſ. This Experiment is certainly the Principal of all: It proves, beyond all Contradiction, the natural Production of Air from the ſolid Subſtances of Bodies; and not only ſo, but in this Manner it will be eaſily found what Weight of Air a Body, of any given Weight will yield; for I obſerve, that the Chalk keeps conſtantly diminiſhing, 'till at laſt it will all be diſſolved.

Cleon. It is true; but it will be too tedious to wait for that: The Event will ſhow, that one Half of the Chalk was turned into Air. But this depends on the Nature of the Chalk, and other Subſtances to be diſſolved; for ſome afford a great deal more, and others leſs, of this fine Matter. As it appears from theſe Experiments, that much Air is produced from Bodies, by the different Methods before-mentioned; ſo there are many others, which equally prove, that the Quantity of Air is really leſſened, conſumed, or abſorbed by Bodies. This is well known to be the Caſe of the Fumes of Sulphur, Fire, living Animals, *&c.* which are all found to leſſen the Quantity of Air; the Manner how this is done is not ſo eaſily underſtood as the Production of Air. But, as it is now Time to put an End to this Converſation, I ſhall recommend to your Peruſal, at your leaſure Hours, what Mr. *Boyle*, Dr. *Hales*, and ſeveral other Authors, have wrote upon this Subject, which will give you all the Satisfaction, in relation to this Matter, that you can deſire.

DIALOGUE III.

Of the Doctrine of WIND. *Its* Nature, Uſe, *and* Cauſes.

Euphroſyne.

THE curious Subjects and Experiments of our laſt Converſation have engaged me to take the firſt Opportunity of troubling you again with my Enquiries. You have ſhewed me how, and in what Manner Air is produced, and I have been, ſince, reading the Authors you recommended, which have highly gratified my Curioſity, and greatly enlarged my Underſtanding; but ſeveral Things yet remain that I do not thoroughly comprehend; and concerning which I muſt beg your Solution of a few Queries relating to this ſurprizing Body of Air. I remember, *Cleonicus*, you ſome Time ago hinted to me, that the WIND was only the *Air in Motion:* This was too ſhort an Account of ſo important a Subject, as the Doctrine of Wind, to ſatisfy me. I doubt not but you can give me a more full, and plain Idea of this Affair.

Cleon. The Subject of Wind, tho' nothing more, in a general Way of defining it, than *Air in Motion*; is, in itſelf, a moſt curious, important, and myſterious Subject, and has employed the moſt learned Pens of Philoſophers to account for it, and the greateſt poetical Geniuſſes to deſcribe it. I need not mention to you the great Benefit, yea, the abſolute Neceſſity it is of to all Mankind: Air, without Motion, I have already obſerved to you is as pernicious as ſtagnant Water, both equally deleterious, or poiſonous to Animals. The dreadful Effects of a motionleſs Air, we find in cloſe Apartments, Priſons, Ships, &c. as is ſufficiently known by the happy Effects produced by Ventilators, and other Methods propoſed for producing a Motion and Circulation of Air. We all find not only Health, but Pleaſure from every gentle Breeze; and, with reſpect to the Ladies in particular, they have not a Faſhion more founded on Philoſophy than that of the FAN, for producing an artificial Wind, whenever they have Occaſion.

Euphroſ. I muſt confeſs, tho' I have been long uſed to this little Inſtrument, I never conſidered the Rationale of it before. I wiſh I could find as much Philoſophy in many other female Trinkets. But now we are upon this Subject, I think I may as well obſerve to you, that a Pair of *Bellows* may be ranged under the ſame Claſs of uſeful Philoſophical Inſtruments.

Cleon. You have rightly obſerved, my *Euphroſyne*; the Conſtruction of the *Bellows* is truly philoſophical, as are many other domeſtic Implements, which are little conſidered in that Light; for when the upper Part of the *Bellows* is lifted up, the Body of Air is lifted from the lower Part, and conſequently, as you obſerve, a Hole is made in that Part, the Air will ruſh in, and fill the hollow Part of this Inſtrument with Wind; but when the Force of the Hand is applied to the upper Part, to depreſs it, it preſſes the internal Valve down upon the Hole, and prevents the Air from returning again that Way: The Body of Air within the *Bellows* is forced to make its Way thro' the narrow Hole of the Pipe, in a very rapid Manner, and, being directed to the Fire, produces that ſtrong Blaſt which is neceſſary for begetting, and increaſing that Element among the Fewel, in order to its burning briſkly.

Euphroſ. This Implement is of much more Conſequence than I ever imagined. I have, many a Time, ſupinely ſat blowing the Fire, without ever conſidering how, and in what Manner, the Effect was produced; which now affords me no ſmall Pleaſure to underſtand: At the ſame Time I can diſcern the Reaſon of a Drawing-ſtove, by encreaſing the Velocity, or Motion of the Air upon the Fire. And, indeed, one would think, our Cook-maids had got ſome Philoſophy by Inſtinct; for when the Fire has been low, I have often obſerved them to ſet the Poker upright before the Grate, and uſed to wonder why they did it, 'till now I obſerve, it divides the Draught of Air, and makes it come in two Streams upon the Fire; it will, therefore, have a greater Force, and raiſe the Fire of Courſe. You'll excuſe this ſhort Digreſſion ——— Pray, go on with your Subjects of more Importance.

Cleon. I like your Remarks ſo well, that I ſhall add another of that Kind to them; and that is, that the very Structure of a *Chimney* depends entirely upon the Motion of the Air; for the

Fire, rarifying the Air in the lower Part of the Chimney, makes it lighter than the Air in the Room, which, as it is heavier and lower, will drive up the lighter Air above the Fire, to the Top of the Chimney, and carry, by this Means, the Smoke along with it: And it is certain, if a Chimney was well made, according to the Rules of Philoſophy, we ſhould not be ſo often moleſted with that very diſagreeable Phænomenon, a ſmoky Room. For it is certain, if there was a proper Draught of Air contrived over the Fire in the Chimney, it would always be ſufficient to carry the Smoke of the Chimney upward, and overcome the Impulſe of the Air on the Top of the Chimney. —— But a ſmoky Chimney is only one bad Effect of Ignorance, and a general Contempt which the Vulgar ſhew to Philoſophy.

Euphroſ. I am fully convinced, that we ſuffer many Inconveniencies of Life for want of being acquainted with the proper Means of removing them. ——— Now you talk of the Wind, it occurs to my Mind, that the Sails of the Wind-mill on yonder Hill, always ſtand a-ſlant to the Wind: I have thought to aſk you the Reaſon of it ſeveral Times, but forgot it, therefore give me Leave to do it now.

Cleon. You could never have propoſed it more opportunely, as the Wind-mill is a very conſiderable Inſtance of the great Benefit Mankind receives from the Motion of the Air. The Force of the Air in Motion, when conſidered, in a large Quantity, is very great upon the Surface of the Sails; if, therefore, thoſe Sails were placed directly before the Wind the Force upon all the four Sails would be ſo great, as to blow down the Mill; and if the Sails were turned ſo as to be placed in the Direction of the Axis on which they are fixed, then the Wind, paſſing one Side and the other, would have no Effect upon them at all; but being placed obliquely, or Side-ways to the Wind, the deſired Effect is produced, *i. e.* the Mill ſtands firm, and the Wind has yet Power enough on the Sails to give them a proper Motion, and to produce Force enough for turning the Millſtones and grinding the Corn; which affords us that ſeaſonable Supply of Flour and Bread in a Time of great Drought, when there is no Rain, and when our Springs, or Rivers fail us, or our Habitations are too far diſtant from them.

Euphroſ. Yet, great as the Advantage of a Wind-mill is, I preſume, it will bear no Compariſon with the Conſtruction and Uſe of a Ship.

Cleon. No otherwiſe than as ſmall to great. For to ſay the Truth, a Ship is one of the moſt noble Machines, and the greateſt Effect of Art that has relation to the Motion of Air: The Oceans themſelves would be uſeleſs to us without the moving Air: The Ships might ſwim in them, but not ſail without Wind: Our Goods are exported to foreign Countries, and the Riches of the *Indies* are wafted to us on the Gales of Wind that fill the Sails of our Shipping. In ſhort, all that depends upon foreign Trade and Commerce is entirely owing to this beneficent Cauſe.

Euphroſ. I can eaſily ſee it would be endleſs to enumerate all the Advantages of the Wind. The next Queſtion that I ſhall trouble you with is, Whether the Philoſophers have ever yet been able to aſcertain the true Cauſe, or Cauſes of the Wind.

Cleon. They have, to a conſiderable Degree: But we muſt diſtinguiſh Winds into three different Sorts; 1. The common, inconſtant, or variable Winds. 2. The Whirl-winds, Tempeſts, and Hurricanes. 3. The conſtant, or ſtated Winds, uſually called *Trade-winds*, and, in ſome Parts of the World, *Monſoons*; and the Reaſon of the laſt of theſe, I muſt firſt give you a ſhort, and general Account of. You muſt know then, my *Euphroſyne*, that as the Earth revolves in its Axis from Weſt to Eaſt, the middle Part of the Earth, and conſequently the Atmoſphere over it is very much heated by the Sun, by which Means it will become more rarified than other Parts remote from the *Equator*, or *Torrid Zone*; on this Account it will be alſo lighter; the heavier Air, therefore, from the polar Parts on either Side, being heavier, will be continually ſetting in towards the *Equator* to reſtore the Equilibrium of the Atmoſphere, which conſtantly alter by the Rarifaction of the Sun. You will from hence eaſily learn, that a Motion will be produced in the Atmoſphere, from North and South, towards the middle Parts of the Earth which would make to us, a conſtant *North Wind*, and to the People on the other Side of the *Equator* a conſtant *South Wind*, if there was nothing elſe intervening.

Euphroſ. So far I am capable of comprehending what you ſay: I wiſh what remains may not be more difficult than this.

Cleon. Indeed it will not; for you have only farther to conſider, that the Parts under the Sun being moſtly heated and rarified, and as the Earth turns Eaſtward, the Point of greateſt Rarification in the Air will be conſtantly ſhifting towards the Weſt; the weſtern and eaſtern Air will, on both Sides, flow towards this Point; but as that on the Weſt meets it, and the other on the Eaſt follows it, the Motion of the weſtern Air will be leſſened, and that of the eaſtern Air increaſed, and, therefore, that of the eaſtern Air will prevail againſt the Motion of the weſtern Air, and ſo there will be a conſtant Eaſt-wind produced in Parts under, and near the *Equator*, if the Body of the Atmoſphere was to be effected in no other Direction; but ſince the ſeveral Parts thereof are urged in two Directions, a Motion will reſult from thence between both, and conſequently a *North-eaſt* Wind be produced on the North-ſide of the *Equator*, and a *South-eaſt* Wind in the ſouthern Hemiſphere; and theſe Currents of Air are what we really find in Nature, and are called by the Sailors the *Trade-winds*; and on your Maps and Globes you will generally find theſe Parts ſhaded, as far as they are ſenſible, which are nearly 30 Degrees on either Side of the *Equator*.

Euphroſ. I have often obſerved thoſe ſhaded Parts, and the Arrows placed among them, all pointing in one Direction; which now I plainly ſee denote the Direction of the Wind; for they point N. E. in one Hemiſphere, and S. E. in the other. But what is the Reaſon that in the *Indian* Ocean, and the *Chineſe* Seas, and ſome other Parts, I obſerve thoſe Arrows lye two by two in different Directions, or pointing towards contrary Parts, with the Names of the Calendar Months by them: Pray, what is the Purport of all this?

Cleon. Theſe, Siſter, are what the Sailors call the *Monſoons*; which for ſix Months of the Year blow one Way, and the other ſix the contrary; the Time being denoted by the Names of the Months affixed to them. In other Parts, they blow but three Months one Way, and three another; and the Direction of theſe Winds are not the ſame as that of the general *Trade-winds*, but ſome of them almoſt contrary to it, as you plainly ſee by the Poſition of the Darts: The Cauſe of which is generally this, that the Sun, during its Paſſage thro' the northern Signs, rarifies the northern Parts of the Atmoſphere moſt, which is ſtill farther increaſed by the great Reflection of the Solar Rays from the ſandy Deſarts of *Arabia*, and the *Indian* Coaſt in general; all this Time the Currents of Air will come into thoſe Seas almoſt in a South-weſt Direction. But when the Sun enters the ſouthern Signs, it carries the Point of greateſt Rarification on the other Side of the *Equator*, occaſioning a contrary Current of Air, or the Wind to change its Courſe during the Winter Months of the Year. For ſuch Sort of Reaſons alſo you will obſerve the Arrows ſhew the Direction of the Winds, in various Directions, along the Coaſt of *Africa*, from the *Canary Iſlands* to the *Cape of Good-Hope*.

Euphroſ. I can ſee, from the Map, pretty well, the Reaſon of all that you have ſaid; but ſhall better underſtand this Subject when I have meditated more upon it. But, before I lay aſide the Map, methinks, I ſee a Repreſentation of ſome Thing like a Conflict of Winds, eſpecially about the *Equator*, on the weſtern Coaſt of *Africa*, and *South-America*.

Cleon. And ſo it really is, in Nature; for over all thoſe Parts, about the Times of the *Equinox*, when the Sun is in the *Equator*, the Motion of the two great Bodies of the Atmoſphere claſh and interfere, producing very great Storms, Tempeſts, and Hurricanes, attended with dreadful Rain, Thunder, Lightning, *&c.* of which you will find a more particular Account in Books of Voyages over thoſe Parts, which would prove a very agreeable Amuſement, were it not for the many affecting Scenes of Miſery and Diſtreſs of the unhappy Seamen, who have, as it were, been made the Sport of theſe Winds, and often fall Victims to their Rage.

Euphroſ. You make me ſhudder almoſt at the Mention of them, which revives in my Mind the Remembrance of that poetical Deſcription of a Storm and Shipwreck in *Virgil*, in the following pathetic Lines.

Then Æolus *hurl'd againſt the Mountain-ſide*
His quiv'ring Spear, and all the God apply'd.

The raging Winds run thro' the hollow Wound,
And dance aloft in Air, and ſkim along the Ground;
When, ſettling on the Sea, the Surges ſweep,
Raiſe liquid Mountains, and diſcloſe the Deep.
South, Eaſt, and Weſt, with mix'd Confuſion roar,
And roll the foaming Billows to the Shore,
The Cables crack, the Sailors fearful Cries
Aſcend, and ſable Night involves the Skies,
And Heav'n it ſelf is raviſh'd from our Eyes.
Loud Peals of Thunder from the Poles enſue;
Then flaſhing Fires the tranſient Light renew.
The Face of Things a frightful Image bears,
And preſent Death in various Forms appears.
Fierce Boreas *drives againſt the flying Sails,*
And rends the Sheets; the raging Billows riſe,
And mount the toſſing Veſſel to the Skies.
Nor can the ſhiv'ring Oars ſuſtain the Blow,
The Galley gives her Side, and turns her Prow;
While thoſe a-ſtern deſcending down the Steep,
Thro' gaping Waves behold the boiling Deep.
Three Ships were hurry'd by the ſouthern Blaſt,
And on the ſecret Shelves with Fury caſt;
Three more fierce Eurus, *in his angry Mood,*
Daſh'd on the Shallows of the moving Sand,
And in Mid-ocean left them moor'd a-land.
From Stem to Stern one was by Waves o'erborne;
The trembling Pilot, from the Rudder torne,
Was headlong hurl'd: The Ship thrice round was toſt,
Then bulg'd at once, and in the Deep was loſt;
And here and there above the Waves were ſeen
Arms, Pictures, precious Goods, and floating Men.
The ſtouteſt Veſſel to the Storm gave Way,
And ſuck'd thro' looſen'd Planks the ruſhing Sea.

Cleon. Storms and Tempeſts are but too frequent at Land as well as Sea. Whatever can give a violent Shock to the Atmoſphere, will produce what we call a high, or ſtrong Wind; and it is eaſy to obſerve, that a Tempeſt at Land has ſome Connection, in its Cauſes, with thoſe at Sea; for as the *Equinoctial*

Suns produce generally the greateſt Commotions in the Atmoſphere about the Equator; ſo we ſenſibly find them extending to our Latitude, and produce that boiſterous, and turbulent Weather we generally experience about *March* and *September.* Beſides theſe general Cauſes of our variable Winds, there are, doubtleſs, many particular ones which I cannot undertake to ſpecify; for whatever can alter the Equipoize of the Atmoſphere, will always produce Motion, or Wind, in the Air. But one great Cauſe of Wind may be ſuppoſed to ariſe from the great Influence the Moon has upon the Atmoſphere, producing *Tides of Air*, as far ſuperior to thoſe of the Ocean, as the Air is lighter, and more free to move than Water. Thoſe conſtant Alternations in the Height of the Atmoſphere muſt neceſſarily induce a Motion through the whole Body of it, greater or leſs in different Parts; which, with many other concurring Cauſes, will variouſly agitate the Body of Air, and produce thoſe common Winds ſo neceſſary to the Well-being of the whole preſent Frame of Nature.

DIALOGUE IV.

Of the Nature *and* Generation *of* METEORS.

Euphroſyne.

I Think I know enough of the Philoſophy of Winds from your laſt Converſation, and what I have read ſince upon that Subject. I have peruſed Dr. *Halley*'s Account in particular, which gives me the higheſt Satisfaction. But the Seaſon is now drawing near, which will preſent us with a Scene of thoſe common Phænomena, which you Philoſophers call by the Name of *Meteors*; but, common as they are, I have met with ſo little, relative to an Explication of their Cauſes, either in common Converſe, or in my general Courſe of Reading, that I know as yet but little of that Affair, and therefore I muſt now deſire your Aſſiſtance for my underſtanding it in this Reſpect.

Cleon. 'Till very lately, Philoſophy has not been the Subject of Converſation, and it is but rarely ſo now. Politics, and pleaſurable Subjects ingroſs the general Attention of Mankind, and trivial Romances take up but too much of our Reading-leiſure; our animal Senſations muſt be firſt gratified at all Events: Dreſs, and Equipage are of too high a Conſequence to be neglected; and, if after all, we can find a little Time for mental Diſquiſitions, and Reſearches, Philoſophy is ſometimes permitted to bring them up in the Rear. We hear the Winds blow, we ſee the Vapours riſe, and obſerve the Clouds driven about in the Air; the deſcending Showers of Rain often alarm us; Froſts and Snow make us ſhudder at the Change of Seaſons, and the awful Phænomena of Thunder and Lightning ſeldom fail to raiſe our Admiration of the Wonders of Omnipotent Power in the upper Regions of the Air; but after they ceaſe, and the Air becomes ſerene and calm, our Amazement ceaſes, and we become ſo far becalmed in our own Minds as ſcarcely to be diſturbed a Moment about the Cauſe or Reaſon of ſuch wonderful Appearances; as if it was only the Philoſophers Buſineſs to be acquainted with the Cauſes of Natural Things, or, that every reaſonable Man was not concerned to regard *the Works of the Lord, or conſider the Operations of his Hands.* But theſe Reflections avail but little with the inconſiderate Part of Mankind; your Emulation is of the nobleſt Sort; you not only ſee and hear in the Animal Way, but rationally enquire into the Reaſon and Cauſes of thoſe Phænomena which ſtrike the Senſes, of which thoſe we call *Meteors* are the principal.

Euphroſ. Pray, ſpend no more Time in complimenting me; but tell me how I am to proceed in my Enquiries, or take your own Method to explain the ſeveral Subjects of our preſent Converſation; for a natural Method is a great Matter in ſuch Caſes.

Cleon. 'Tis true, Method is a principal Thing, all the Logicians agree; and therefore, in the firſt Place, the VAPOURS ariſing from the Earth by the Heat of the Sun, and the internal Warmth of the Earth, are the Subjects of our preſent Enquiry.

Euphroſ. You have already explained to me, in a great Meaſure, the phyſical Cauſe of the Aſcent of Vapours in a former Conference; which, if I remember right, you ſaid conſiſted in a repulſive Force between the Parts of Matter, by which, ſuch as were ſeparated from the Surfaces of humid and other Kind of Bodies, were repelled, and driven up into the Air in the Form of *Vapours.*

Cleon. Your Memory renders you an excellent Pupil. That is certainly the firſt Step Nature takes in forming Vapours. And now we muſt conſider the ſecond, *viz.* The Reaſon of their riſing into the Air to the Height they do. This is owing to the Vapour being lighter, in an equal Bulk, than the Air; and you will find no Difficulty in conceiving, that a lighter Body muſt neceſſarily riſe in a heavier one; as a Piece of Cork, placed at the Bottom of a Veſſel of Water, and there left to itſelf, will riſe to the Top immediately, by Reaſon of the ſuperior Weight and Denſity of the Water: But this, however, I ſhall explain to you more fully, when we come to the Principles of *Hydroſtatics.*

Euphroſ. If the Vapour be Bulk for Bulk lighter than Air, I know it muſt neceſſarily riſe in it, and I ſee it every Day confirmed by natural Experience; but I ſhould not have thought thus, ſince I can ſo plainly ſee the Vapour, but the Air is ſo fine that I cannot ſee it at all, and therefore I ſhould have thought that had been the lighteſt.

Cleon. You think as moſt People do; but you ſee from hence, how neceſſary it is to have our vulgar Thoughts corrected, and to have the Art of Thinking, and Reaſoning right. Philoſophy is natural Logic; by it we are convinced, that the reſpective Weights of Bodies do not depend on their Viſibility. The Fiſh, in the Element of Water, ſee no more the Parts of Water than we do thoſe of Air; but the Buoy, and other Objects floating on the Surface, are ſtill the Objects of their Sight, in the ſame Manner as Vapours and Clouds are of ours.

Euphroſ. Well, I am almoſt aſhamed of my Ignorance. But you know, *Cleonicus*, every one muſt have Time to learn. But ſince the Vapours being lighter muſt riſe in the Air, why do they not, for ever keep riſing, and ſo, by Degrees, get out of our Sight, and be diſſipated quite away?

Cleon. To underſtand the Reaſon of this, you will recollect, that I told you the Denſity and Weight of the Air was every where variable, being greateſt of all at the Surface of the Earth, and decreaſing gradually, upwards; therefore, tho' the Air near the Earth be heavier than the Vapour; yet, as its Gravity continually decreaſes, it will, at length, become lighter than Vapour in its upper Parts, and in one particular Region between, it will be equally heavy with the Vapours themſelves; whence it muſt follow, that the Vapours will riſe from the Surface of the Earth to this Part of the Atmoſphere; and ſince all the Air above is lighter, they cannot poſſibly riſe higher; here therefore they will remain in Equilibrio with the Air, and appear under the Form, and take upon them the Denomination of CLOUDS. The Clouds, thus produced, are ſeldom quieſcent, or without Motion, more or leſs. As the Air becomes variouſly agitated, the Clouds are carried about and driven to and fro therein.

Euphroſ. I ſeem, by what you have ſaid, to have a tolerable Notion of the Matter: But, pray, whence comes it to paſs, that the Clouds, in thoſe upper Regions of the Air, have thoſe very different Aſpects and Poſitions, ſometimes riſing high in the Air, ranged in Form of aerial Mountains, and variegated with beautiful Colours of Light; at other Times, they, ſeemingly, approach much nearer to us, and appear with horrid Aſpects, black and lowering.

Cleon. The general Cauſe of theſe Appearances ariſes from the different Weight of the Air at different Times; were the Weight of the Air to continue always the ſame, the Clouds would always be ſeen at the ſame Height; but many Cauſes concurring to alter the Gravity of the Air, over any particular Place, if it becomes greater, the Clouds will riſe higher, and one Series of Clouds above another, reflecting the Light of the Sun above, or below the Horizon, which paints the delightful Views, and Landſkips in the Air you juſt now mentioned; at other Times, when the Gravity of the Air is leſſened, the Clouds deſcend of Courſe, and, running together, mix, and condenſe into a large, and more opake Body; in ſuch Caſes they generally fill the viſible Atmoſphere, eclipſe the Sun from our Sight, ſhut out the Light of the ſuperior Air, and make all dark, and gloomy about us below.

Euphroſ. Pray, *Cleonicus*, will it be an impertinent Queſtion to aſk, what may be the *Height of the Clouds?*

Cleon. Not in the leaſt; ſo far from it, that it is commonly obſerved, People are more inquiſitive about the Height of the Clouds, than any other Circumſtance belonging to them; and it is not to be wondered at; for, perhaps, there is not a more curious Problem in Philoſophy than to determine the Height of the Clouds.

Euphroſ. Do you think I could underſtand any thing of the Method of doing it?

Cleon. Yes; you will not only underſtand it, but may eaſily practiſe it too.

Euphroſ. Indeed! Then I ſhould think myſelf Somebody, if I were able to meaſure the Height of the Clouds. But, pray, how muſt I proceed in that Affair?

Cleon. It is done by means of an *half ſecond Pendulum*, and a Flaſh of Lightening. ———

Euphroſ. Of Lightening, do you ſay! Dear me, I am ſo terrified at the Appearance of Lightening, that I can ſcarce ſhew my Face to the Clouds, how then can I meaſure the Height of them?

Cleon. You are like the People going to *Italy*, who would fain get thither, without aſcending the *Alps*.——If you would be a Philoſopher, you muſt have Courage enough to face the Artillery of a Cloud. However, to be ſerious, I am far from inſinuating, that there is no Danger from a Flaſh of Lightening; we have but too many affecting Inſtances of the Contrary; but as, on the one Hand, there is no Occaſion to be fool-hardy in gazing on the opening Cloud; ſo, on the other, it would diſcover too great a Puſillanimity to ſhut our Eyes againſt every Flaſh of Lightening.

Euphroſ. Well, then, you may truſt me for Courage in this Reſpect; but what Skill does it require to manage the *Pendulum?*

Cleon. Little Skill, Time, or Labour is here required. The Method is thus:———You ſee this Pendulum is nothing more than a Ball, ſuſpended by this String, which when I hang it upon a Pin, it will move, or vibrate about it, as you here ſee.——It is made juſt 9 Inches and eight Tenths of an Inch long, that it may vibrate in *half a Second* of Time: The Pendulum, thus ſuſpended, you take in your Hand, and hold it on one Side, ready to let go, when you ſee the Flaſh, which you are ſuppoſed to be waiting for.———The Moment it lightens, you let go the Pendulum, and then tell the Number of Vibrations that happen be-

between that Time and the Moment you hear the Stroke of Thunder.———And thus you have meaſured the Time which the Sound takes up in coming from the Cloud to the Ear.

Euphroſ. All this is nothing more than what I can eaſily perform. But how am I, from thence, to underſtand the Diſtance, or Height of the Cloud?

Cleon. Very eaſily; for it is well known, from a Multitude of Experiments that have been made, that the Velocity of Sound is uniformly at the Rate of 1142 Feet per Second; therefore, in Half a Second it moves 571 Feet, and conſequently, if you multiply this Number 571, by the Number of Half-ſeconds, which are made between the Flaſh and the Stroke, that will expreſs the Number of Feet in the *Height* of the Cloud, if it be nearly over your Head; or its *Diſtance* from you in any other Situation; and in this Manner you will continue meaſuring the Diſtance of the Cloud all the Time it is paſſing from the Zenith to the Horizon; and, by that Means, become acquainted with the Extent of the viſible Hemiſphere of the Clouds.

Euphroſ. Such a Practice as this will afford me as much Pleaſure as ſuch Kind of Weather will admit of. I intend to take the firſt Opportunity for this Purpoſe; but I ſhall take care to have you preſent, as well for Company as Aſſiſtance.——— But, for the preſent, I muſt proceed in my Queries: Pleaſe, therefore, to let me know, in the next Place, what are the general Cauſes of *Rain*, *Hail*, *Snow*, *Froſts*, *&c.*

Cleon. In theſe Particulars I will give you all the Satisfaction I can. The general Cauſe of Rain is, as I ſaid before, the Alteration of the Weight of the Air; by which Means, the Clouds deſcend, intermix and embody together, and thereby become much heavier; the Weight now forcing the aqueous Particles together, they attract each other, in Conſequence of which, the Cloud becomes liquified, or diſſolved into Water, much after the ſame Manner as you ſee a heated Steam or Vapour become condenſed, or run into Drops againſt any cold Surface. The Water of the Cloud, as faſt as it is produced by this Coaleſcence, and Condenſation, being heavier than the Air, muſt neceſſarily diſtil through it, and deſcend in Drops of Rain; and thus from the Baſis, or lower Part of the Cloud, proceed thoſe Showers which the Bounty of Providence beſtows upon every Part of the Earth, as there is Occaſion, or Neceſſity for them.

Euphroſ. This ſeems to be a very natural and genuine Account of Rain; but as it proceeds from natural and ſeemingly accidental Cauſes, I ſhould wonder how it comes to paſs, that we have not conſtantly too much, or too little Rain, for any one Place; as Chance alone can never be ſuppoſed to ſteer clear of Extremes; but I obſerve, you mentioned the *Hand of Providence* in the Caſe, which gives an eaſy Solution of this, otherwiſe, wonderful Event.

Cleon. There is no other Way of accounting for ſuch an Oeconomy in the Clouds. Such a juſt and neceſſary Diſtillation, and Diſtribution of Waters, from the grand Alembic of the Atmoſphere could never proceed but from the Superintendence, Wiſdom, and Direction, of that omnipotent Chemiſt, in whoſe Hands are all the ſecondary Powers of Nature, to vary their Operations as he ſees conſiſtent with the general Good of Mankind.

Euphroſ. I am ſatisfied of the Truth of what you have obſerved; but may we not reckon the Winds another general Cauſe of Rain, by driving the Clouds together, and forcing them to coaleſce, condenſe, and become heavier, and therefore to fall in Rain?

Cleon. Moſt aſſuredly: You have expreſſed this Matter as well as any Philoſopher could have done. Thoſe Winds that blow from the Ocean, as the *South* and *Weſt-winds*, bring large Recruits of Vapours to the Clouds, and therefore are more inclined to produce Rain than others which come off the Land, as the *North* and *North-Eaſt*-winds, which generally diſperſe the Vapours, and blow the Clouds away; as is thus elegantly expreſſed by *Ovid.*

> *Fierce* Boreas *flies,*
> *To puff away the Clouds, and purge the Skies:*
> *Serenely while he blows, the Vapours driv'n,*
> *Diſcover Heav'n to Earth, and Earth to Heav'n.*
>
> DRYD. OVID.

The ſame Poet very philoſophically introduces the South-wind, as bringing Fogs, Miſts, and Rain upon the Earth.

> *The South-wind Night and Horror brings,*
> *And Fogs are ſhaken from his flaggy Wings.*
> *From his divided Beard two Streams he pours,*
> *His Head and rheumy Eyes diſtil in Show'rs:*
> *With Rain his Robe and heavy Mantle flow,*
> *And lazy Miſts are low'ring on his Brow.*
>
> DRYD. OVID.

Euphroſ. You have pretty well ſatisfied me, as to Wind and Rain; but how do you account for Fogs and Miſts, which oftentimes ſo far obſcure the Body of the Atmoſphere, that we can ſcarcely ſee any Thing at a Diſtance from us?

Cleon. Every Sort of Vapour of this Kind, that goes under the Name of Fogs and Miſts, is only a denſer Kind of Vapour, which is too heavy to be immediately raiſed up into the Air. The Condenſation of this Vapour is either owing to a greater Degree of Warmth in the Surface of the Earth and Water, which throws it off in a greater Proportion than common, and faſter than it can riſe through the Atmoſphere; or elſe, to the Want of a ſufficient Degree of Heat in the Atmoſphere to attenuate thoſe Vapours, and increaſe their Elaſticity, and conſequently their Rarity: For Want of theſe Qualities they are detained in the lower Part of the Atmoſphere in large and opake Particles, viſible themſelves to the Eye; but preventing Viſion of other Objects through them.

Euphroſ. The Caſe then, I conceive, is ſomewhat analogous to One's Breath in a cold Morning, which then, I can plainly perceive; whereas, in a warmer Air, the Particles of One's Breath become inviſible, and therefore, inſenſibly fly off, and mix with the Air. In like Manner, as I have often ſeen, after a foggy Morning, and the Sun has aſcended high enough to warm the Atmoſphere with its Beams, the Miſt, or Fog has been, by Degrees, diſſolved, and diſpelled in the Form of Clouds; or, at other Times, totally vaniſhed away. Agreeable to which, I remember the following Verſes of *Milton.*

Ye Miſts and Exhalations, that now riſe,
From Hill or ſteamy Lake, duſky and grey,
'Till the Sun paint your fleecy Skirts with Gold:
Either to deck with Clouds th' uncolour'd Sky,
Or wet the thirſty Earth with falling Show'rs.

MILTON's Paradiſe Loſt.

You have ſatisfied my Curioſity with regard to *Fogs* and *Miſts*; but how am I to underſtand the Reaſon of that Phænomenon which we uſually call a *Hoar-Froſt?* I know it proceeds from Cold; but ſhould be glad to know the Manner how.

Cleon. Cold is only a comparative Term, and ſignifies nothing more than a leſs Degree of Heat, which we uſually call a moderate Warmth. Now it is well known, that many Bodies will liquify with one Degree of Heat, and become fixed with another: This is the Caſe of all *Metals*, *Salts*, *Oils*, *Water*, *&c.* With one Degree of Warmth, Water will appear in a fluid State; with a leſs Degree, the Particles will be found to be fixed, congealed, (or as we uſually term it) frozen. Thus the Vapours, in a warm Air, are in a fluid State, and when condenſed by the Coldneſs of the Evening, and deſcend, they adhere to the Piles of Graſs in the liquid Form of pearly Drops, which, in that Caſe, we commonly call DEW; but theſe very Particles in a colder Air will be fixed, and while they are floating in the Air, they make what is called a *Rimy-Fog*, or *frozen Miſt.* When theſe Particles deſcend, they fall upon the Graſs, and the Twigs of Shrubs and Trees, and make a beautiful Incruſtation, which is called a *Hoar*, or *White-Froſt*, in Contradiſtinction to another Sort, which is called the *Black-Froſt*, only becauſe it does not appear white; and this *Black-Froſt* differs from the other in nothing more than this, that it is not attended with a Miſt or Fog.

Euphroſ. The Account you have given of *freezing*, in the Parts of Water, ſeems, to me, very natural; but how am I to underſtand the Manner of thoſe Particles becoming *fixed*, which I think you have not ſufficiently explained?

Cleon. It is certain, from Experience, that Fluidity in the Parts of moſt Bodies is promoted (I will not ſay occaſioned) by Heat; and Fixity (or freezing in Water) is the Effect of Cold, or a leſs Degree of Heat: But to pretend to deſcribe the Mode of Action, or Proceſs of Nature in this Reſpect, I will not pretend to; for what I ſhould naturally think was likely to account for freezing is inconſiſtent with another Phænomenon of that Affair, *viz.* that all theſe Bodies, in a fixed State, have a larger Bulk than in a fluid one. This Water, ſet to freezing in a cylindric Veſſel, will be congealed into a larger Bulk of ICE, which is nothing but *Water fixed.* On the other Hand, a fixed Metal, as *Lead*, *Tin*, *&c.* when melted, or liquified, runs into a leſſer Space, or becomes of a leſs Bulk. Theſe Appearances make it ſomewhat difficult to account for the Nature of freezing, or Congealation, ſo perfectly as one might wiſh; and therefore you will excuſe my ſaying any Thing more than I know upon this Subject.

Euphroſ. Very readily, dear *Cleonicus*; it is certainly over-doing the Thing, to load any Theory with Conjectures; nor was I ever fond of any Hypothetical Reaſoning, tho' I ſhould prefer your Opinion, if I choſe to be inſtructed in that ſuperficial Way. ——— I am glad you have put me into ſo good a Way of thinking about this cold, but very curious Subject, which is ſo elegantly deſcribed by the late ingenious Dr. *Broome*, in the following Lines.

When ſtormy Winter, from the frozen North,
Borne on his icy Chariot, iſſues forth,
The blaſted Groves their verdant Pride reſign,
And Waters, harden'd into Cryſtal, ſhine:
Sharp blows the Rigour of the piercing Winds,
And the broad Flood, as with a Breaſt-plate, binds;
Ev'n the proud Seas forget in Tides to roll,
Beneath the freezing of the northern Pole;
There Waves on Waves in ſolid Mountains riſe,
And Alps *of Ice invade the wond'ring Skies;*
But if warm Winds a warmer Air reſtore,
And ſofter Breezes bring a genial Show'r,
The genial Show'r revives the chearful Plain,
And the huge Hills flow down into the Main.

BROOME.

Cleon. The Doctor has expreſſed the Thing very elegantly; and, at your Leiſure, you may conſult Mr. *Thompſon*'s poetical Philoſophy at large, on this Head, in his *Winter Seaſon*; and the next Opportunity that offers I ſhall take to explain the Nature of other Meteors to you.

DIALOGUE V.

The Nature and Generation of METEORS, *continued.* *Of* SNOW, HAIL, LIGHTENING, THUNDER, *Aurora Borealis*, &c.

Euphroſyne.

SINCE our laſt Interview, the Weather, having been very cold, gave me an Opportunity of obſerving, more particularly, the various Phænomena of freezing, which you then explained to me; and among other Things, the Fleaks of Snow very much entertained me as they fell on the Leads before the Window. Theſe I viewed with a magnifying Glaſs, and thought I perceived ſomething very beautiful and regular in their Form. Pray, what Account do the Philoſophers give of this ſtriking Phænomenon we call SNOW?

Cleon. It is a Subject every Way worthy of your Speculation, and one of the moſt curious Productions of Nature. This has been already intimated to you by your Glaſs, and will be farther evident, when you view them thro' a larger Magnifier. The Philoſophy of *Snow*, in ſhort, is this. ——— The Particles of all Salts have a natural Diſpoſition to run together, and conſtitute ſome particular, or ſpecial Form: and as thoſe Particles are originally, and, in themſelves, tranſparent, and clear as Glaſs, or Cryſtal, this natural Action of ſhooting into thoſe peculiar Forms is what they call CRYSTALIZATION; and the Particles ſo combined and configurated are called the Cryſtals of ſuch and ſuch Salts, or Metals. On this Head we ſhall be much larger hereafter; it is ſufficient, at preſent, that you conſider Water as an inſipid, fluid Salt; and that the upper Region of the Air, where the Parts of nitrous Salts abound, this Diſpoſition to freezing or Congealation, is very great in the Winter-ſeaſons, when the Atmoſphere is much leſs heated by the Sun's Rays: The *Aqueous Particles*, therefore, mixing with *Nitre*, immediately ſhoot into *Cryſtals*, and form the original Parts of *Snow*, whoſe Figure is truly wonderful, as being ſtrictly mathematical; for from one Point, as a Center, they irradiate into ſix different, but very beautiful Parts, more or leſs connected, and variegated with an Appearance of a vegetable Form, or Nature. Theſe ſnowy Cryſtals, being of this hexagonal and ramous Form, makes them apt to hitch into, and hang upon one another, 'till they make a Body too heavy to be ſupported by the Air, and then they deſcend in the Form of *Flakes of Snow*, which are ſmaller or larger, according to the Degree of Cold which forms them: And if you examine one of thoſe Flakes of Snow by your Glaſs, you will plainly ſee the Truth of what I have now mentioned, *viz.* that they are only a Collection of a great Number of thoſe original, regular Cryſtals. Theſe being of a large Bulk, in reſpect of their Weight, make them deſcend with a gentle and irregular Motion thro' the Air; ſo that a Shower of Snow, tho' common with us, and therefore not ſo much regarded, is, in itſelf, a moſt beautiful Thing, and is looked upon by the Natives of ſouthern Climes, on their Arrival here, as the moſt extraordinary and amazing Phænomenon of Nature.

Euphroſ. What you now obſerve, I know to be Fact; having been in Company with a Creole Lady, juſt arrived in *England* from *Jamaica*, a Country, where Snow and Ice have been heard of, but were never ſeen; I ſhall never forget how it affected her Mind, when ſhe firſt ſaw this new Wonder of deſcending Snow. It was a conſiderable Time before ſhe could ſpeak a Word, ſtanding, as it were, in ſilent Amazement for ſeveral Minutes; nor could ſhe be prevailed upon to turn her Eyes from this unuſual Sight, for more than half an Hour, 'till her Attention to this Phænomenon had greatly impaired her Health by taking a very great Cold, and other Illneſs that followed: ——— And when ſhe was ſhewn a Piece of Ice, ſhe could not conceive how it was poſſible for Water to be transformed into ſuch wet, and ſlippery Glaſs, as ſhe called it. One may ſee, by theſe Inſtances, how little Mankind are apt to be affected by the moſt wonderful Operations of Nature, when they become the common Subject of our Senſes. ——— But, pray, *Cleonicus*, have you any Experiments by which you can illuſtrate this Doctrine of Snow?

Cleon. Yes; and a very curious one, which is thus: —— I take this tall Phial of *Aqua-fortis*, and ſet it by the Fire, 'till it is warm; —— then I put in it Filings of pure Silver; a few at a Time, and you ſee, they preſently diſſolve with a briſk Ebullition: —— At length, you ſee the Silver diſſolve very ſlowly, which is a Sign, that the Fluid has taken up as much as is neceſſary for our Purpoſe.

Euphroſ. All this I obſerve with the greateſt Pleaſure. But, pray, let me aſk you one Thing, by the Way: What is that Copper-coloured Fume that ariſes at the Mouth of the Phial, every Time you put in the Silver?

Cleon. That is a Sort of *Arſenic*, evaporating as the Silver diſſolves, and it is the ſtrongeſt Poiſon in Nature; but of this I ſhall give a more particular Account, when we ſpeak of the Nature of Metals. ———I wipe the Phial clean, and place this Solution of Silver in a cold Place in the Window; ——— it ſoon becomes clear and tranſparent; ——— as it cools, the Silver Particles, like thoſe of Water, will ſhoot into Cryſtals; —— and ſeveral of theſe running together will form a Flake of Silver Snow, and viſibly deſcend, thro' the Fluid, to the Bottom of the Phial. It is only your waiting a little while, and you will perceive it very evidently.

Euphroſ. I ſhall wait with Pleaſure for this extraordinary Sight. —— The Solution is quite clear, and almoſt cold. —— If I am not miſtaken, I think I ſaw ſome Thing like a Flake deſcend: ——— I ſee two, three, and more, very plainly deſcend, one after another: ——— They now deſcend ſo very faſt, as perfectly to repreſent *a Shower of Silver Snow.* ——— Thoſe Flakes of Snow lie one upon another at the Bottom of the Phial like real Snow upon the Ground. ——— I think this one of the fineſt Experiments I ever ſaw with my Eyes!

Cleon. It is certainly ſo; and if you take out your Glaſs, and view thoſe Cryſtals, as they lie at the Bottom, you will obſerve the ſame Geometrical Form in them, as you did in *Aqueous*

Snow. I could contrive this Experiment to be ſtill much more ſenſible, but it would take up too much of our Time at preſent.

Euphroſ. What you have ſhewn me is very ſufficient: The natural and artificial Snow have ſo exact a Reſemblance, that my Glaſs will not diſcover any Difference. I ſee the ſame regular Ramifications in one as in the other; and, pray, how long will this Silver Snow remain at the Bottom without diſſolving?

Cleon. 'Till the Weather becomes warmer. For while it remains cold, theſe Cryſtals will not be reſolved, even tho' you pour off the fluid Part, and keep them dry in the Phial.

Euphroſ. Well, it is all very wonderful. ——— And when I conſider the Earth covered with Snow, and the Houſes cloathed therewith, and the Trees bending under the Weight of it, the bleak Scene reminds me of another Deſcription of Dr. *Broome*, which is very poetical, in theſe Lines.

He from aërial Treaſures downwards pours,
Sheets of unſully'd Snow in lucid Show'rs;
Flake after Flake, thro' Air, thick-wav'ring flies,
'Till one vaſt ſhining Waſte all Nature lies.
Then the proud Hills a Virgin Whiteneſs ſhed;
A dazzling Brightneſs glitters from the Mead:
The hoary Trees reflect a ſilver Show,
And Groves beneath the lovely Burden bow.

BROOME.

Cleon. To this I may add another Deſcription of the ſame Nature, from *Homer*, tranſlated by Mr. *Pope*, as follows.

As when high Jove *his ſharp Artillery forms,*
And opes his cloudy Magazine of Storms;
In Winter's bleak uncomfortable Rain,
A ſnowy Inundation hides the Plain:
He ſtills the Winds, and bids the Skies to ſleep,
Then pours the ſilent Tempeſt, thick and deep:
And firſt the Mountain Tops are cover'd o'er;
Then the green Fields, and then the ſandy Shore:

Bent with the Weight the nodding Woods are ſeen,
And one bright Waſte hides all the Works of Men:
The circling Seas alone abſorbing all,
Drink the diſſolving Fleeces as they fall.

POPE's Iliad.

Beſides a good deal more, of this Kind, which you will find in *Thompſon*'s *Seaſons*, and other Pieces of philoſophical Poetry.

Euphroſ. I fear I have almoſt tired you on the Subject of *Snow*; but you are yet to acquaint me with the Nature of HAIL. I preſume I ſhall not be ſo tedious to you on that Head.

Cleon. The Conſideration of *Hail* may be diſpatched in a few Words. For you are to conſider, that it ſeldom or ever *hails* but when the Air is heavy, and the Vapours aſcend to a great Height in it, which is moſtly the Caſe in Summer-time, when Storms and Hail are much more frequent than in Winter. In the higher Regions of the Air, the Cold is much more intenſe, and therefore, it is preſumed, a much greater Quantity of Nitre is there to be found; this cauſes a more immediate and ſtronger Congealation of the *aqueous Particles*, and binds them firmly into a Body of Ice of various Magnitudes, or Sizes, according to the Degrees of Cold. Theſe becoming conſiderably heavy deſcend from thoſe Heights with great Rapidity, in the Form of a *Shower of Hail*, and when the Hail-ſtones are very large, they ſtrike with a very great Force, as we very often experience to our Coſt.

Euphroſ. This I well know; as it was not long before your Return from College, that all our Windows were broke by an eaſtern Storm of Hail; and I remember one of thoſe Hail-ſtones were more than half an Inch in Diameter; and further I obſerved, thoſe large Hail-ſtones were not near a round Figure, but oblong, and flattiſh. Pray, how do you account for the Form and Size of Hail-ſtones?

Cleon. There is ſomething difficult in the Theory of Hail; 'tis not eaſy to conceive, how ſuch large Bodies ſhould be inſtantly formed, for they can increaſe, in Bulk, but very little in the Time of their Deſcent; however, it is owing to the general Principle of freezing, after the ſame Manner as we ſee Cryſtals of Copper are inſtantly formed in Solutions of that Metal,

Metal with a requiſite Degree of Cold. Then, as to their Figure, we know ſtill leſs the Reaſon, as there ſeems to be nothing regular in it, unleſs ſomething of a conical Form. We may ſuppoſe it is principally owing to its Motion in the Air while forming.

Euphroſ. Pray, what are the largeſt Sizes of Hail-ſtones that have been obſerved?

Cleon. I have never ſeen any myſelf exceeding $\frac{3}{4}$ of an Inch in Diameter; but I have been frequently informed of others much larger. ——— A Lady particularly told me, that ſhe ſaw a Hail-ſtorm abroad, where many of the Stones were as large as a *Seville Orange.* —— And a Gentleman aſſured me, that he ſaw Hail-ſtones fall as large as common Turnips, and ſomewhat of the ſame Form; ſeveral of which he meaſured; one of which was full eleven Inches round. Theſe are the largeſt Sizes I have ever met with in my Enquiries.

Euphroſ. Such Storms of Hail, I ſhould think, were very formidable, and muſt produce ſtill more direful Effects than thoſe deſcribed by *Garth* in theſe Lines.

Thus when ſome Storm its Cryſtal Quarry rends,
And Jove *in ratt'ling Showers of Ice deſcends;*
Mount Athos *ſhakes the Foreſts on his Brow,*
While down his wounded Sides freſh Torrents flow,
And Leaves and Limbs of Trees o'er-ſpread the Vale below.

GARTH.

And again *Virgil.*

As when thick Hail comes ratt'ling in the Wind,
The Plowman, Paſſenger, and lab'ring Hind,
For Shelter to the neighbouring Coverts fly,
Or hous'd, or ſafe in hollow Caverns lie;
But that o'er-blown, when Heav'n above them ſmiles,
Return to Travel, and renew their Toils.

DRYD. VIRGIL.

And laſtly, my fav'rite Author on this Subject:

He from looſe Vapours, with an icy Chain,
Binds the round Hail, and moulds the harden'd Rain;

The ſtony Tempeſt, with a ruſhing Sound,
Beats the firm Glebe, reſulting from the Ground;
Swiftly it falls, and as it falls invades
The riſing Herb, or breaks the ſpreading Blades;
While infant Flow'rs that rais'd their blooming Heads,
Cruſh'd by its Fury, ſink into their Beds.

BROOME.

The Courſe of our Enquiries leads me next to aſk your Opinion concerning LIGHTNING and THUNDER.

Cleon. With reſpect to theſe *fiery Meteors*, as they are commonly called, I ſhall give you the beſt Account of them that I can learn from Sir *Iſaac Newton*, who alone has reaſoned juſtly concerning the Nature of Fire in general. From him we learn, that, when by the conſtant Heat of the Sun, in the Summer Time, great Quantities of Exhalations from ſulphureous and other combuſtible Matters are raiſed into the upper Regions of the Air, and theſe meeting and mixing with the Nitre, an Incaleſcence will immediately enſue, and oftentimes real Accenſion, or Production of Flame; and this, if it happens in the Evening, or Night-Time, is what is vulgarly called Lightning, if it happens in any one particular Part of the Heavens only: But when the Atmoſphere is more generally replete with theſe combuſtible Exhalations, they make a more general Conflagration, and burn with one continued Flame; illuminating all that Part of the Heavens in a moſt tremendous Manner to thoſe who have not been uſed to ſee or think about ſuch Things. This the Philoſophers call the *Aurora Borealis*, *i. e.* the Northern Lights. But, indeed, there ſeldom a Summer paſſes, but more or leſs of this Kind may be obſerved about the Time of Autumn, not only in the northern, but in any other Part of the Heavens.

Euphroſ. Pray, *Cleonicus*, what kind of Experiments have you to illuſtrate this wonderful Phænomenon of fiery Meteors?

Cleon. Many of different Kinds; ſome of which you may eaſily ſee tried without being ſhocked at the Effect; for Inſtance; ——— You ſee, I take the red-hot Poker, and dropping a few Corns of Gun-powder on it, they immediately take Fire, and flaſh like Lightning; for Gun-powder is nothing but Sulphur, Nitre, and Coal mixt together. The Coal preſently takes

Fire by the ſmalleſt Spark, by which the Sulphur and Nitre are melted, and burſt into Flame, juſt as they do in the Heavens.

Euphroſ. Well! this I like to ſee. I am not fearful at ſuch ſmall Exploſions. What other Experiments of this Kind can you ſhew me with Safety?

Cleon. Several, one of which is thus: ——— You ſee, I take this large *Florence* Flaſk, and put into it a ſmall Quantity of Oil of Vitriol, with four Times its Quantity of Water, which will produce a conſiderable Heat, as you will find by applying your Hand to the Glaſs. —— Then I mix with it a few Steel-filings; —— upon this, you ſee an Ebullition, and a white Vapour ariſe. ——— In the next Place, I apply a Candle to the iſſuing Vapour, and it immediately takes Fire, with a bright Fulmination, or Flaſh like Lightning. ——— In the laſt Place, by applying the Candle ſeveral Times, you ſee, the like *Coruſcations*, and ſometimes the Flame fills the Body of the Glaſs, where it circulates about, and appears like an *Aurora Borealis* in Miniature. ——— And thus, you ſee, how far we can imitate Nature by Art; and that in the moſt terrible and tremendous of all her Works: Such Subjects as theſe afford the ſublimeſt Themes, not only to the Philoſopher, but alſo to the Divine, and the Poet. The Philoſopher inveſtigates the Nature of the Thing; the Theologiſt ſhews its important Uſe in the Œconomy of Providence; and the Poet renders it ſtill more ſtriking by the Force of Expreſſion and Deſcription. An Inſtance of this we have from *Lucan.*

Such, while Earth trembles, and Heav'n thunders loud,
Darts the ſwift Lightning from the rending Cloud;
Fierce thro' the Day it breaks, and in its Flight
The dreadful Blaſt confounds the Gazer's Sight;
Reſiſtleſs in its Courſe delights to rove,
And cleaves the Temples of its Maſter Jove:
Alike wheree'er it paſſes or returns,
With equal Rage the fell Deſtroyer burns;
Then with a Whirl, full in its Strength, retires,
And recollects the Force of all its ſcatter'd Fires.

ROWE'S LUCAN.

Another Inſtance we have from the *Iliad.*

As when by Lightnings Jove's *ætherial Pow'r*
Foretels the rattling Hail or weighty Show'r,
Or ſends ſoft Snows to whiten all the Shore,
Or bids the brazen Throat of War to roar;
By Fits, one Flaſh ſucceeds as one expires,
And Heav'n flames thick with momentary Fires.

POPE'S ILIAD.

Euphroſ. Theſe are very beautiful Imitations, indeed; and ſince you have recommended Mr. *Thompſon's Seaſons*, I remember a Paſſage there, as much to the Purpoſe on the *Aurora Borealis*, which he thus very poetically deſcribes.

Oft in this Seaſon, ſilent from the North,
A Blaze of Meteors ſhoots; enſweeping firſt
The lower Skies, they all at once converge
High to the Crown of Heav'n, and all at once,
Relapſing quick, as quickly reaſcend,
And mix and thwart, extinguiſh and renew,
All Æther courſing in a Maze of Light.
From Look to Look contagious thro' the Croud
The Pannic runs, and into wond'rous Shapes
Th' Appearance throws: Armies, in meet Array,
Throng'd with aerial Spears and Steeds of Fire;
'Till the long Lines of full extended War,
In bleeding Fight commix'd, the ſanguine Flood
Rolls a broad Slaughter o'er the Plains of Heav'n.

THOMP. SEASONS.

But to bring up the Rear of theſe dire Phænomena, let *Thunder* next employ our Attention. Pray, what is the Nature and Cauſe of that?

Cleon. THUNDER, properly ſpeaking, is neither a Phænomenon, nor a Meteor, as it conſiſts altogether in Sound; for you are to know, that when the combuſtible Matters in the Heavens take Fire, or kindle into a Flame, if there be no Reſiſtance, they only explode, or flaſh away without any Thing more than the

Phænomenon of Lightning, which is generally the Caſe of a rare and unconfined Air, as we often ſee in the autumnal Evenings; but the Caſe is far otherwiſe, when theſe fermenting Matters are contained in the denſe Body of a Cloud. The great Reſiſtance which they meet with, in this Caſe, occaſions an equal Power of re-action, which is ſpent wholly on the Body of the Cloud and ambient Air; which Air, by this Means, having its Vibrations excited in the higheſt Degree, occaſions thoſe very loud Reports from the upper Regions, and expanding over all the inferior Parts of the Atmoſphere, propagate thoſe awful Sounds, which we call THUNDER; for Sound, you muſt know by the Way, conſiſts only in the pulſive Motion of the Air, which I ſhall more fully explain to you, when I come to ſpeak of the more pleaſing Modulations of this Medium, producing the more agreeable Notes, which make Harmony and Muſic.

Euphroſ. I cannot tell which will entertain me moſt. The loud Voice of Thunder ſo ſtrangely affects the Powers of my Mind, as to be agreeable and terrible at the ſame Time; and you ſee, I am a Devotee to Muſic, by my conſtant Application to the Practice and Study of it; and I muſt ſay this for myſelf, that, if I have any Ingenuity, it lies, principally in my Fingers Ends. I ſhall long for a Lecture on Muſic; but, at preſent, pray, go on with your *celeſtial Thorough-baſs*.

Cleon. To tell you the plain Truth, tho' I am a young Man, I am yet an old-faſhioned Philoſopher, and cannot help thinking, that Sir *Iſaac Newton*'s Method of explaining the Cauſes of theſe great Effects is much preferable to any new Hypotheſis of the Moderns. He tells us, in his Treatiſe of Optics, that Lightning in the Heavens, is analogous to the Flaſhing of Gun-powder unconfined, and that Thunder is a ſimilar Effect to the Report of a Gun from the Powder kindled, but confined in the Barrel; and to thoſe other chymical Exploſions, from what they call *Pulvis & Aurum Fulminans*, which are Powders; ſuch as, when laid upon the Point of a Knife, and held over a lighted Candle, explode with a very ſudden and loud Report; which Sort of Experiments are ſo ſhocking, that I ſhall not terrify you with them.

Euphroſ. I ſhall take your Word, *Cleonicus*, for that, as I am not fond of ſeeing any Thing that is ſhocking and terrible; and ſo affected is my Mind with the Thoughts of Thunder, that, when any Thing of that Kind is likely to happen, I generally get into a Corner, as it were, to avoid the Blow. I had much rather read the Deſcription of it in the Poet; and it even makes me ſhudder then, as in the following Lines of Dr. *Broome*.

Mean Time, from ev'ry Region of the Sky,
Red burning Bolts in forky Vengeance fly:
Dreadfully bright o'er Seas and Earth they glare,
And Burſts of Thunder rend th' encumber'd Air;
At once the Thunders of th' Almighty ſound,
Heav'n lowers, deſcend the Floods, and rocks the Ground.

BROOME.

But more particularly the Deſcription of a Thunder-ſtorm by Mr. *Thompſon*, in the following Lines.

How chang'd the Scene! in blazing Height of Noon,
The Sun, oppreſs'd, is plung'd in thickeſt Gloom.
Still Horror reigns, a dreary Twilight round
Of ſtruggling Night, and Day malignant mix'd.
Far to the hot Æquator crouding faſt,
Where, highly rarify'd, the yielding Air
Admits their Stream, inceſſant Vapours roll,
Amazing Clouds on Clouds continual heap'd;
Or whirl'd tempeſtuous by the guſty Wind,
Or ſilent borne along, heavy and ſlow,
With the big Stores of ſtreaming Oceans charg'd.
Mean Time, amid theſe upper Seas, condens'd
Around the cold aërial Mountain's Brow,
And by conflicting Wings together daſh'd,
The Thunder holds his black tremendous Throne;
From Cloud to Cloud the rending Lightnings rage;
'Till, in the furious Elemental War
Diſſolv'd, the whole precipitated Maſs
Unbroken Floods and ſolid Torrents pours.

THOMP. SEASONS.

I recollect at preſent but one Thing more to enquire about, relative to theſe Subjects, and that is what has often filled me with the greateſt Horror; I mean, what is uſually called a *Thunder Bolt*. Pray, what is your Opinion of that?

Cleon. This is an Affair of the moſt ſolemn Conſideration, and muſt certainly fill every reflecting Mind with Horror, when we conſider the many dreadful Effects that are often produced by it: Inſtant Death is the immediate Effect of its Stroke in Animals.——The ſtrongeſt Trees are rent and torn a ſunder——The fineſt Buildings at once demoliſhed, and the hardeſt Metals in a Moment diſſolved.——Such are the Effects of the greateſt and moſt formidable Powers in Nature. The Subſtance of theſe Bolts conſiſts of a compact and undiſſolved Body of ignited Matter, which has not time to explode in the Air, but is darted, with the Velocity of Light itſelf, to the Objects on the Surface of the Earth, which it ſtrikes with an inconceivable and irreſiſtible Force, deſtroying the Nature and Texture of every Thing that ſtands in its Way. Not only our Hiſtories, but even our Memories retain but too many Inſtances of theſe diſmal Effects. We may conſider the Matter of Lightning in three different States; the Firſt is, that, in which it only explodes, and flaſhes away without any Force to do Harm; the Second is, when it explodes with greater Force and Denſity; the Effects of this are oftentimes too ſenſible at a Diſtance, ſtriking the unhappy Spectator with Blindneſs, and ſetting Fire to Stacks of Corn, Houſes, *&c.* the Third State is that of the Thunder-bolt; but I have ſaid enough on this Head. We ſhall take the next Opportunity to conſider the Nature of *Electricity*; a Subject nearly allied to this, but whoſe Phænomena and Effects are more innocent, and much more entertaining.

DIALOGUE VI.

On the Nature, Phænomena, *and* Experiments *of* ELECTRICITY.

Euphroſyne.

YOU very agreeably concluded our laſt Converſation by promiſing to give an Account of the Nature of Electricity, which you then told me had ſome Relation to the Nature of Lightning, and Thunder.

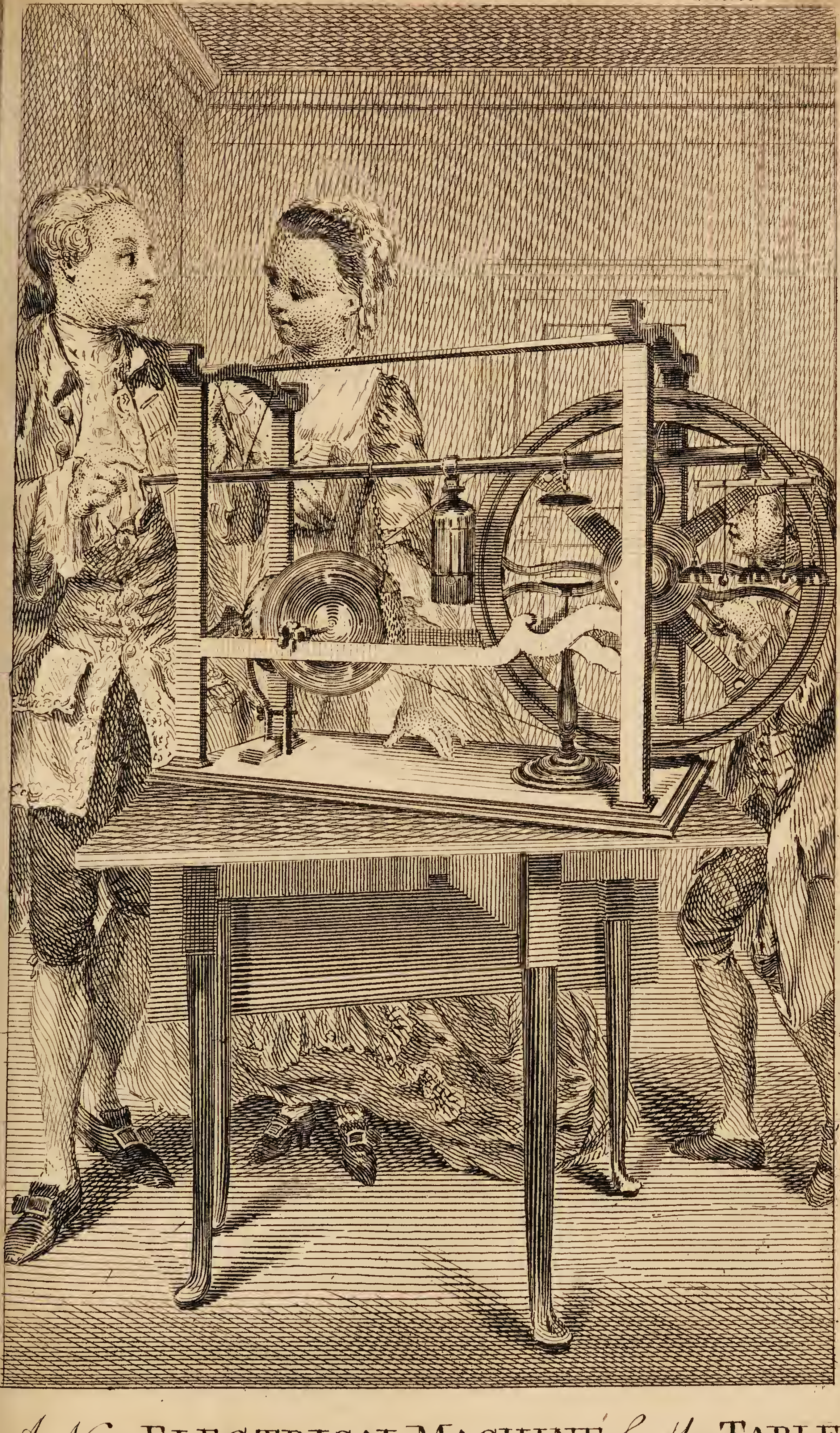
Cleon. I did; and you may now expect as much on that Subject as I know of the Matter myſelf, which, to ſay the Truth, is not a great deal. However, its Relation to Lightning and Thunder is obvious, and conſiſts in the following Particulars. 1. It conſiſts of a fine etherial Matter, which, when ſufficiently condenſed, appears in the Form of Fire, and ſuch is the Caſe of the Matter of Lightning. 2. In a State of Condenſation, this electrical Matter, like that of Lightning, is ſtrongly elaſtic and exploſive. 3. It will produce, when ſufficiently denſe, the Effects ſimilar to thoſe of Lightning, in burning, and ſetting Fire to other Bodies. 4. It produces, in the Exploſion, a very ſenſible Report, which may be eſteemed a Kind of Thunder in Minuature. 5. The Effects of ſuch an Exploſion is very ſenſible, and ſometimes very great on the animal Syſtem; ſo as to produce, not only Uneaſineſs and Pain to a great Degree; but even to inflict Death itſelf; for not only Birds and ſmaller Animals, but Man himſelf has fallen a Victim to its Force. 6. The Velocity of electrical Matter is like that of Lightning, almoſt inſtantaneous, and probably the ſame with that of Light itſelf.

Euphroſ. Theſe are wonderful Properties of Matter indeed! Pray, how came they at firſt to be diſcovered?

Cleon. The Properties of Electricity, like moſt other Things, received a gradual Diſcovery and Improvement; and it is now become almoſt a Science. It has been always obſerved, that Amber, Jett, Sealing-wax, Glaſs, and other elaſtic and poliſhed Bodies, would, upon rubbing, attract and repel light Bodies, as Hairs, Feathers, Down, Duſt, *&c.* and as this Property was moſt conſpicuous in Amber, which in *Greek* is called ἐλέκτρον, Electron; therefore this peculiar Power of that Body was called *Electricity.*

Euphroſ. But I ſuppoſe, but little of this Affair was known till lately: How far, pray, might the Knowledge of the Antients extend in this Particular?

Cleon. It was ſcarce any thing more than a few entertaining Experiments; for by rubbing the Pieces of Amber, Sealing-wax, *&c.* they would often innocently amuſe themſelves



A New ELECTRICAL MACHINE for the TABLE

with the Attraction and Repulſion of light Bodies of different Kinds and Forms; ſome of which I ſhall ſhew you for your preſent Entertainment. —— Thus, you ſee, this Piece of Amber in the Head of my Cane, when gently rub'd by my Glove, it attracts the Hairs, the Feathers, and theſe ſmall Pieces of Leaf-Gold. —— I rub this Tube of Glaſs in the ſame Manner, and it attracts thoſe Objects ſtill more ſtrongly.

Euphroſ. Well! this is very pretty indeed; but I obſerve, they are not only attracted, but ſoon afterward repelled from the Tube. Pray, *Cleonicus*, how is that to be accounted for?

Cleon. Why, truly, my *Euphroſyne*, this is a Kind of *occult* Philoſophy: However, you muſt underſtand, that, upon rubbing of the Tube, there is a Motion produced of this Electric Æther from the Parts round about it towards the Tube, or Piece of Amber; and theſe fine Particles, in their Way, lay hold of thoſe light Bodies, and carry them with themſelves to the Tube; ſo that, in reality, tho' this Appearance ſeems in itſelf an Attraction, it is really produced by the Impulſe of theſe ethereal Particles; and when theſe light Bodies have touch'd the Tube, and become themſelves poſſeſs'd of the electric Matter to a proper Degree, they then fly off, and, I belive, in this Caſe, may be properly ſaid to be *repelled* by the Tube.

Euphroſ. But, pray, *Cleonicus*, can you, by any Experiments, ſhew me this Matter of Electricity; for otherwiſe it is talking to me in the Dark?

Cleon. Yes; come with me into this dark Room, and then you will view it in its proper Light. ——

Euphroſ. —— Well! it is dark enough ſure. —— What am I to ſee here?

Cleon. You will now ſee in the Dark what you could not before perceive in the Light. —— I rub the Tube with a Piece of Silk, and you ſee the Sparks of Fire. —— I rub it ſtill more briſkly, and you ſee the Sparks changed into Flaſhes; —— Flaſhes many Inches in Length, and very much reſembling the forked Lightning of the Skies.

Euphroſ. I do; and it is amazing, as well as very entertaining to behold. —— I not only ſee, but hear it likewiſe. What is it I hear like the Crackling of a green Leaf in the Fire?

Cleon. The crackling Noiſe you hear is occaſion'd thus, After I have given a briſk Stroke downward upon the Tube, I carry my Hand quick along by the Side of it, upwards, at a ſmall Diſtance; by this Means the electric Matter is condenſed between the Hand and the Tube, in the ſeveral Parts of it, which occaſions the ſmall ſucceſſive Exploſions, or Snappings, which you hear.

Euphroſ. Well! theſe Corruſcations and Exploſions are very ſurprizing indeed; I could never have thought there were ſuch Powers in Nature, had you not convinced me of them by Experiment, —— and is it this Fire that I now ſee, that fetches and carries thoſe light Bodies to and from the Tube?

Cleon. It is in the light Room the inviſible Agent that produces theſe Effects. At preſent we ſhall leave our dark Apartment to explain another Property. —— You obſerve, my *Euphroſyne*, that, when the Piece of Leaf-Gold, or downy Feather is once repelled from the Tube, I purſue it with the Tube, and conſtantly keep repelling of it; nor, if the Tube be ſtrongly excited, will it come to it again, till it has touched ſome other Body.

Euphroſ. 'Tis pleaſant enough to ſee how you perſecute the Feather. They ſeem to endeavour avoiding the Tube by every Method of Flight, but how do you account for the Reaſon of this odd and comical Appearance?

Cleon. Theſe Bodies in contact with the Tube are fill'd with the electric Virtue, which, as I ſaid before, as ſoon as they have received to a ſufficient Degree, will be repelled, and will be continually repelled ſo long as they are overcharg'd with this electrical Matter; for we ſhall always find by Experience, that, when any two Bodies are poſſeſs'd with one and the ſame Power, whether of Electricity, Magnetiſm, or Gravity, there will be always a Circumſtance, in which they will conſtantly repel each other; but when one of thoſe Bodies comes to touch another, not ſo replete with this Virtue, it will impart the Surplus of its Electricity to that other Body, and be reduced again to its original State; and hence the Reaſon why they fly ſo quickly backward and forward between the Tube and the Table. Since as faſt as they receive it at one, they diſcharge it at the other.

Euphroſ. I know not whether I underſtand you perfectly. Do you mean, that Bodies in general are poſſeſs'd of a certain Quantity of this Force, and that they receive more by the excited Tube, and by that Means become repelled; and that, when ſuch a Body touches another that is not electrified, it loſes all that is over and above its natural Quantity, and then is liable to be attracted again?

Cleon. That is the very Caſe, ſo far as I have hitherto proceeded; but one Thing more is to be obſerved, that Bodies will be liable to be repelled, not only when they have too much, but alſo when they have too little of the electrical Matter; and further, that ſome Bodies will fill others with a greater Quantity of Electricity than they naturally have, in which Caſe they are ſaid to *electrify them poſitively*; and other Bodies are found, that, when excited by rubbing, will diſpoſſeſs ſuch as touch them of a Part of what they naturally contain, and theſe are then ſaid to be *electrified negatively*.

Euphroſ. This poſitive and negative Doctrine of Electricity is ſomething ſo new to me, and the Subject of Electricity ſuch as I am ſo little acquainted with, that I ſcarcely know what to make of it, or how to faſhion my Intellects for underſtanding it, I muſt beg your Aſſiſtance in this Caſe, if poſſible, by Experiments.

Cleon. That I ſhall do very readily. Now obſerve, I tye a fine Feather to a Thread of Silk, and electrify it with the Tube very ſtrongly. —— It is now conſtantly repelled by the Tube, you ſee. —— I now take the Stick of Sealing-wax, and excite it, and upon applying it to the Feather, it immediately attracts it. —— So likewiſe the Piece of Leaf-Gold is conſtantly repelled by the glaſs Tube. —— But you obſerve, it is immediately attracted by the excited Wax. In ſhort, every Thing repelled by Glaſs is attracted by Sealing-wax, Amber, Jett, and ſuch-like Bodies; and as theſe conſiſt for the moſt Part of reſinous Subſtances, it occaſions the two-fold Diſtinction of a *reſinous* and *vitreous Electricity*. But upon a more nice Conſideration of this Affair by the Moderns, it is found, that Glaſs electrifies Bodies by adding to their natural Quantity, and other Bodies by diminiſhing it, therefore we have now the new Diſtinction of *Glaſs* electrifying *poſitively*, and *reſinous* Bodies *negatively*. Some other Experiments

ments will tend to illuſtrate this Affair more fully. But before we come to them, I muſt obſerve to you, that ſome Bodies will communicate Electricity from one to another, and others will not. Thus, if I hang a Feather by a flaxen Thread, the Electricity will paſs from the Feather through that Thread to any Piece of Wood, or metalline Subſtance, it is ſuſpended by, and this Thread is, in ſuch a Caſe, term'd the *Conductor of Electricity*. ——— By this Means, you obſerve, when I apply the excited Tube to the Feather, it is conſtantly attracted; becauſe the electrical Matter is carried off by the Thread as faſt as it is received by the Tube. —— On the other Hand, you ſee, another Feather ſuſpended by a ſilken String, and another by a Horſe-hair, both perfectly dry, and upon applying the Tube you ſee they are conſtantly repelled; the Reaſon of which is, that thoſe Bodies will not of themſelves conduct, or carry off the Electricity from the Feather, being ſome how or other diſqualified for that Purpoſe, and are on this Account ranged among the Number of *electrical Bodies*, and ſometimes are called *Electrics per Se*; whereas thoſe that conduct Electricity are call'd *Non Electrics*. Thus much was neceſſary to premiſe, by Way of Definition; but what relates to the *Rational* of the various *Phænomena* of *Electricity*, you will be better able to underſtand, after you have ſeen them illuſtrated by Experiment; for which Purpoſe I have provided you this large Machine.

Euphroſ. A large and elegant Machine indeed; but I obſerve, you have here a large glaſs Globe. To what Purpoſe does that ſerve? I ſuppoſe, to anſwer the End of the glaſs Tube more compleatly, does it not, *Cleonicus?*

Cleon. Yes, that is the Deſign of it; for having a large Surface the Electricity is excited, when the Globe is put in Motion, from the Attrition of the Cuſhion behind, in a much larger Degree than we can produce it from the Tube, and more conſtantly, by turning the Wheel; ſo that upon the Whole, it is much better fitted to anſwer the Purpoſes of Experiments.

Euphroſ. I ſee you have here a large Gun-barrel ſuſpended by ſilken Strings over the Globe. I partly gueſs the Reaſon of that, from what you ſaid of the Feather's being ſuſpended by a ſilk or Hair-line.

Cleon. That you may do very nearly; for by Means of the Conductor, which is the braſs Equipage hanging from the Barrel againſt the Globe, the electrical Matter is convey'd to the Barrel, but can go no further, by Reaſon of the renitent Quality of the ſilken Strings. By this Contrivance, the electric Fluid, thrown out by the Glaſs, will be collected and accumulated in the Barrel, ready to be diſpenſed in ſmall Quantities to every non-electric Body that ſhall approach it, in the Form of a Spark, and ſnap, or elſe in a continued fine Stream of Fire.—This you ſee and hear, by my approaching the Knuckle of my Finger to the Barrel. —— Now you are to do the like, *Euphroſyne.*

Euphroſ. Truly, as there is Fire in the Caſe, I am afraid. ——Does it not give you Pain, *Cleonicus?*

Cleon. Not in the leaſt. You'll ſcarcely feel it.—— Apply your Finger within a Quarter of an Inch, and it will do.——

Euphroſ. Well! I did not think I was ſo Faint-hearted. I find a ſtrange Reluctance to trying this Experiment, tho' there ſeems to be nothing in it. ——— Well! I'll pluck up my Courage and try. ——— Is my Finger near enough now?—— Dear me! it ſtrikes before I was aware; but the Senſation is rather agreeable than otherwiſe. —— I can now take off as many Sparks as I pleaſe, ——— and by continuing my Knuckle near the Barrel, I perceive a conſtant Flame of purple Fire flowing toward it. ——— Theſe Things are very wonderful as well as pleaſant. I could not have thought there had been any ſuch Powers in Nature.

Cleon. You expreſs the Sentiments of all who firſt view theſe curious Appearances. I ſhall now proceed to ſhew you ſtill greater Things than theſe. —— You obſerve here a four Ounce Phial, filled with Steel-filings, coated on the Out-ſide with a Piece of Leaf-Tin, with an Iron Wire and Loop upon it; alſo, in the Top, you obſerve a large Iron Wire paſs thro' the Cork among the Steel-filings to the Bottom; the outer Part of this Wire is turn'd into the Form of a Hook, by which it may be hung on the Gun-barrel, —— as thus you ſee it.

Euphroſ. Very good! And to what Purpoſe is all this Apparatus in the Phial?

Cleon. By this Contrivance, the Force, or Power of electrical Fluid may be increaſed to a conſiderable Degree. You did but juſt feel the Spark before, but now, if you take the Phial in one Hand, and a Spark from the Barrel with the Finger of the other, you will find a more ſenſible Effect; and this you muſt do, before you can properly be ſaid to know the Nature, or Power of Electricity.

Euphroſ. I thought you would bring me into a Scrape e'er long about this electrical Fire and Force. I am loath to try the Experiment with this Phial in Armour; it ſeems to require a martial Courage, and how can you expect me to ſtand Fire before I know the Nature of the Artillery? —— Pray, *Cleonicus*, can't I underſtand it by ſeeing you do it yourſelf?

Cleon. Not in the leaſt; you might as well expect to be cur'd of an Ague by my taking the Bark for you. —— However, it will not be fair to deſire you to try the Experiment till you have ſeen that no Harm can accrue by it, and therefore I will try it firſt. —— I take the Phial in my Right-hand; —— with my Left I take off the Spark. —— The Effect is an odd Kind of Shock in the Elbows; ——— but it is over in a Minute. —— I ſhall take Care to moderate the Force to you, and therefore you may try it without Fear.

Euphroſ. What you adviſe, or injoin, I think myſelf oblig'd to ſubmit to; therefore whirle the Globe about, and charge the Phial. ——— I take it in my Hand; ——— and now for the Snap. ——— I am electrified in Truth. ——— It made me jump again. What an unaccountable odd Kind of Stroke it gives to my Elbows! ——— I hope I have nothing more to ſuffer worſe than this; if there be, I ſhall not very well like it.

Cleon. You may comfort yourſelf, that the Worſt is paſt. This is the *Coupe de Grace*, which is what all that adventure in Electricity muſt expect to meet with; —— but tho' you make ſo much of this Affair, I can aſſure you, I have ſeen many a Lady with ſo much Preſence of Mind as to ſuſtain many of theſe Shocks one after another.

Euphroſ. In every Age we may expect a *Semiramis*, or a *Boadicia*; but nevertheleſs, the generality of our Sex will never think themſelves deſigned to bear Arms. When you expect Mankind to ſport with your electrical Fire and Shocks, you ought to have your Room fill'd with Officers of the Military Order, and not to expect ſuch Courage from Females.

Cleon. What would you think, my *Euphroſyne*, if I were to tell you, that I have ſeen a Lady with greater Intrepidity encounter the electrical Efforts than any one of our Sex; and I can aſſure you from Experience, that I have ſeen a greater Number of Gentlemen than of Ladies refuſe to ſtand the Shock; and it altogether depends upon the peculiar Make and Frame of a Perſon's Mind; for I have more than once obſerved a Perſon, who had ſignalized himſelf for Valour in the Field of Battle, could not by any Means be prevailed on to take the Phial in his Hand; but enough of this.——We proceed to our Experiments, of which I ſhall entertain you with a ſelect Number of thoſe which are moſt conſiderable, leaving the Reſt for your Amuſement at your leiſure Hours when alone.

Euphroſ. If you ſhew me ſome of the Principal it will be ſufficient. I ſhall learn the Method of Practice from them. Pray, what will you begin with?

Cleon. You ſee here a ſemicircular Piece of Cane, with ſeveral Feathers ſuſpended by ſilken and linen Threads alternately; theſe I place at a ſmall Diſtance from the Globe, and when it is excited, you obſerve all the Feathers hanging by the linen Threads will be immediately attracted to the Globe, and conſtantly kept in an oblique Poſition, and directed ſeverally to the Centre of the Globe; while thoſe between them on ſilken Strings ſeem but little affected, and remain in their perpendicular Poſition.

Euphroſ. This is a very pleaſant and pertinent Experiment. I plainly perceive the Drift of it, you hereby ſhew me, that the Feathers on the linen Threads loſe all their electric Matter as faſt as they receive it, and therefore are conſtantly attracted; while thoſe ſuſpended by ſilken Strings, retaining their electric Matter firſt received from the Globe, will always afterwards be repell'd by it. Pray, what is your next Experiment?

Cleon. This Wire you ſee has three large plumy Feathers fix'd on the Top of it, and I put it into the End of the Barrel. —— Upon turning the Globe, you ſee the Feathers immediately briſtle out, and all the Plumage expanding itſelf every Way as far as poſſible. ——— If I approach my Finger to the Feathers, the *Plumulæ* all bend themſelves to my Finger. —— If I move my Finger this Way or that, they all move after it, as if alive. —— If I put my Finger to the Barrel, and take off a Spark, the *Plu-*

mulæ all collapſe, and fall cloſe to the Feather. —— My Finger removed, they become erect, and briſtle out as before.

Euphroſ. Nothing can be a more delightful Spectacle. I preſume the Plumage puts on this Appearance from having the electric Matter equal in all the Parts, by which the *Plumulæ* conſtantly extend themſelves, and repel each other; but when the Finger approaches, they become attracted by it, and diſcharge their electric Fluid in it. Alſo, when the Finger takes the Spark from the Barrel, it not only draws the Electricity from the Barrel, but likewiſe from the Feathers themſelves, by which Means the Plumage becomes unelectrified, and naturally falls down. —— I preſume I am right ſo far, *Cleonicus.*

Cleon. You have given the true Reaſon of the Phænomenon; and the next Experiment I ſhall ſhew you is to be accounted for the ſame Way. —— I take this whole Leaf of Gold, and tumble it together upon this Plate. —— I bring the Plate under the Gun-barrel, and you ſee the Gold-leaf riſe from the Plate, expand itſelf out into a perfect Plane, —— with one Corner to the Gun-barrel, and the Oppoſite one to the Plate, —— moving very quickly backward and forward between both. —— I lower the Plate to a proper Diſtance, and you ſee the Motion of the Leaf ceaſes by Degrees, and it becomes ſuſpended *in Equilibrio* between both.

Euphroſ. This is a moſt wonderful and curious Sight. I now ſee it is poſſible for the heavieſt Bodies to be ſuſpended in the Air upon nothing; for I can plainly perceive there is a conſiderable Diſtance between the Points of the Leaf-Gold and the Barrel and Plate.

Cleon. But you muſt be aware of Miſtakes, my *Euphroſyne.* The ſuſpended Leaf of Gold is, as it were, ſupported by Pillars of Fire; for it is by Means of the Electricity which it receives from the Barrel, and communicates to the Plate, that it is ſuſpended equally between both; and this will appear in the Form of Fire, when we put to the Window-ſhutters, and make the Room dark. —— For now you ſee the Experiment in its proper Light.

Euphroſ. I do. —— I ſee it connected with the Barrel and Plate at either Corner by a Stream of Fire. ——

Cleon. ——— I put my Finger on the Barrel. ——— And the Leaf falls down at once on the Plate. ——— My Finger taken off, the Leaf riſes up, and becomes ſuſpended as before.

Euphroſ. We may now open the Windows again, as I have ſeen the Manner of this Experiment thoroughly. Pray, what is your next Phænomenon?

Cleon. I take ſome fine Sand on this Plate, and place it on the Pedeſtal under the Barrel, and you ſee, as it were, a Hurricane enſue among the Particles of Sand. ——— They are agitated upwards and downwards, and driven every Way in Commotion, 'till at laſt, they are all diſperſed, and, as it were, blown off from the Plate.

Euphroſ. This is ſomething of a merry Scene, and has much the Appearance of an artificial Storm.

Cleon. Another curious Experiment is this. An eight-pointed Plate of Iron, in form of a Star, freely moveable upon an Axis, and placed on the End of the electrified Barrel, you will ſee a bright Flame on each of the Points. [*Window ſhut.*]

Euphroſ. It is a moſt pleaſing Sight, indeed! I obſerve every Point illuminated with a ſmall Flame. ———

Cleon. ——— I put my Finger on the Barrel, and all thoſe little Lamps are extinguiſhed. ——— I take my Finger off, and in an Inſtant, they are lighted up again. ——— But what ſee you now, my *Euphroſyne?*

Euphroſ. See! a wonderful Sight, a real Circle of Fire. Pray, what have you done to make that Appearance?

Cleon. Only put the Star into a circular Motion, by ſtriking it; and now the ſeveral luminous Points ſucceed ſo faſt to each other, as to make the Appearance of a Circle of Fire. ——— This Circle, you ſee, diſappears too, in taking the Spark from the Barrel. [*Window opened.*]

Euphroſ. Why this would paſs for a Sort of Conjuration in Countries where Electricity has not been heard of.

Cleon. It would ſo; and nothing would be more eaſy than to impoſe upon People this Way; but it happened very luckily to fall into ſuch Hands, whoſe Intereſt was rather to divulge than make a Secret of it; for, by the next Experiment, you will obſerve, that nothing is eaſier than to draw Fire from every Part of your Body, and that without darkening the Room.

Euphroſ. This is ſomething more extraordinary ſtill; but ſure I do not underſtand you.

Cleon. Why, then you ſhall try the Experiment upon me, and prove the Truth of it that Way. ——— I take this little Board with four Glaſs-feet, and ſtand upon it: ——— Then I take the Chain in my Hand, which is connected with the Gun-barrel at the other End. ——— This conducts the Electricity to all the Parts of my Body; — but it cannot go off by Reaſon of the Glaſs below, which will not conduct Electricity. ——— I am therefore, in this Situation, properly ſaid to be electrified. — I now hold out my Hand to you. Pray, take off a Spark. —

Euphroſ. Amazing indeed! ——— The Spark proceeds from your Hand moſt evidently to my Finger: — From your Cloaths it is the ſame: — From your Legs: — From your very Shoes, the Fire iſſues out. ——— Pray, what Kind of Senſation does it cauſe in you?

Cleon. That you will beſt know by taking my Place. [*She ſtands on the Board*] ——— Don't be afraid; but hold out your Hand. ——— I take off the Spark from your Finger: ——— From your Shoulder: ——— From your Foot: ——— From your Noſe: ——— And to conclude all, my *Euphroſyne*, let me ſalute you in that Situation; ——— but you ſee we endeavour it in vain. ——— Our Lips cannot touch, repelled, as it were, by the irreſiſtible Force of electrical Fire.

Euphroſ. Well! were it not for Experiments, it would be impoſſible for a Perſon to gain Belief of ſuch Things. I could never have thought of a Perſon's being all on Fire without knowing it; or that Fire could have been extracted from every Part, without any more Senſation than the touching of a Pin's Point.

Cleon. Theſe wonderful Diſcoveries are all of modern Date. The Gentleman is now living, who firſt accidentally diſcovered the prodigious Increaſe of Force, by Means of the coated Phial, and of Courſe, was the firſt who ſuſtained that very great Shock. He paid for the Diſcovery indeed, by the Privation of his Senſes for ſome Time. This was the celebrated Mr. *Muſchenbroek*, the preſent Profeſſor of Philoſophy at *Leyden*; and indeed, this is the Foundation of moſt of the Improvements and great Diſcoveries that have been made in Electricity to this Time; I ſhall take an Opportunity of ſhewing you, at another Time, that the electrical Virtue will go through any Number of Perſons, communicating with each other, and give them a Shock all at the ſame Inſtant of Time; but at preſent, we ſhall try the Experiment in a leſs Circuit, *i. e.* only you, myſelf, and your little Lap-dog, *Chloe*, between us both.

Euphroſ. How can you be ſo cruel, dear *Cleonicus*, as to think of my little *Chloe?* ——— The pretty, tender Creature will be at leaſt frightened out of its Wits, if not expire with the Shock. Pray, let me beg the dear little Creature off.

Cleon. By no Means, my *Euphroſyne*, *Chloe* muſt not be excuſed; if ſhe dies, it will be in her Miſtreſs's Arms; and where can ſhe make her Exit with more Satisfaction? ——— But I only joke with you, it will not do her the leaſt Harm. It may make her yelp perhaps, and that will be all.

Euphroſ. I can't ſay but I'm more afraid of my little *Chloe* than I am of myſelf. However, ſhe ſhall know for once what it is to be electrified. —— And here ſhe is; but pray, let me hold her faſt in my Arm.

Cleon. That you may do, and with the other Hand, take hold of the Chain, which hangs from the Phial, and let me, with one Hand, take hold of *Chloe*'s Foot, and with the other, I ſhall take off a Spark, when the Bottle is charged. —— Are you ready?

Euphroſ. I am. —— You may touch off the Spark as ſoon as you pleaſe. ——— Heavens! ſhe's gone, and I'm afraid has broke her Neck in the Fall. ——— Poor, little Creature! how it cried out! ——— I can aſſure you, I was almoſt ready to ſtumble myſelf, for the Shock was greater now than before. For the future, you muſt excuſe both me and my *Chloe* from any ſuch Kind of Experiments; for we ſhall both remember this as long as we live.

Cleon. What would you ſay, if you were to ſee your favourite Linnet ſtruck dead with the Shock?

Euphroſ. I would not ſee it, nor ſuffer it for the World. This Electricity, I'm afraid, will prove a terrible Affair to my poor little Dog and Birds. Why ſhould you take Delight in ſuch cruel Experiments?

Cleon. Were it not for them, Mankind would not be informed how far the Power of Nature could operate, and conſequently, in many Caſes, what could, or could not be done. Nay, the Life of a Bird, or a Mouſe, might probably ſave that of a Man, and therefore the Experiments tend rather to a good, than a bad End; tho' in Appearance they ſeem incompatable with our Reaſon, and more delicate Paſſions. Accordingly therefore, I have prepared this little Titmoſe to be a ſubſtitute Victim for your Linnet, and you muſt not flinch to ſee it ſacrificed on this Altar by electrical Fire. ——— I ſhall call my Servant in to be the Executioner. ——— Here, *John*, take this Bird, with a Chain about its Leg, and when I ſpeak, bring its Head within $\frac{1}{4}$ of an Inch of the Barrel.

John. —— Yes, Sir, I am ready to obey your Commands.

Cleon. Gently now bring its Head to the Barrel. ———

John. The Bird's dead, by my Soul! ———

Euphroſ. Poor Creature! It is dead indeed! How ſudden a Death is this! What a violent Stroke it muſt be on the Head of that little Creature to deprive it of Life in an Inſtant! But theſe Scenes are ſo affecting, I could wiſh to have them chang'd for Experiments of another Sort.

Cleon. Well! I ſhall entertain you now with a few others which are more innocent and leſs offenſive. ——— You ſee I take this crooked Wire, and hang it to the Gun-Barrel with a Weight at the Bottom to keep it ſteady, and on the ſharp Point at Top I place this long Piece of Braſs, nicely balanced with a Ball at each End, ſo as to move very freely. ——— This braſs Fly is now electrified, and when any non-electric Body is applied to it, it will appear to be attracted this Way and that, and may be carried round as often as you pleaſe. —— Thus my Finger held near it brings it immediately ſo near, as to diſcharge its Fire with a Snap. — I take my Finger on the other Side, and the braſs Ball follows it; in ſhort, my Finger ſeems to attract it, as the Load-ſtone does the Magnetic Needle.

Euphroſ. This is really a very pretty Phænomenon! And now you ſpeak of the Magnetic Needle, I ſhould be glad if you would ſatisfy my Curioſity in one Particular; that is, to let me ſee, if the Magnetic Virtue is affected by this electrical Matter, or if the Needle be attracted by the Load-ſtone in the ſame Manner, when electrified, as when not.

Cleon. You will ſee this Matter determined by Experiment. I have a Needle at Hand for that Purpoſe. ——— I place it on the Point of the Wire. —— Tho' it is now electrified ſtrongly, yet it obſerves its true Point of Variation. —— I approach the Magnet, and it is attracted; ——— I remove the Magnet, and it returns to its former Poſition. ——— I apply the other End of the Load-ſtone, and it is repelled. ——— On removing it, it returns again to its Variation as before. —— In ſhort, the Needle, like the Pieces of Braſs, is attracted by every non-electric Body, but repelled by the Magnet only.

Euphroſ. I am now fully convinced, that thoſe two wonderful Powers do not interfere with each other, or hinder each others Operation. Pray, how does the electrical Virtue affect the Motion of Fluids?

Cleon. In a very curious Manner, in three Reſpects. Firſt, It alters the Direction of the Motion. 2dly, It accelerates, or increaſes the Motion. And 3dly, It renders the Fluid luminous, or gives it the Appearance of Fire itſelf.

Euphroſ. Such Experiments as theſe greatly delight me, and I hope will not be very troubleſome to yourſelf.

Cleon. Not in the leaſt, my *Euphroſyne.* We have always Inſtruments ready at Hand to exhibit theſe Appearances. —— With this braſs Syringe, and Pipe at the End with a ſmall Bore, I ſhall make a very fine Stream of Water, which, by the Force of the Piſton, flies to a great Diſtance. —— At the ſame Time, take you this glaſs Tube in your Hand, and when you ſee the ſlender Stream, give it a Stroke or two with your Glove, and hold it near to the Stream, and you will ſee the Stream immediately attracted by it, and bent conſiderably out of its firſt Direction towards the Tube.

Euphroſ. I am ready with the Glaſs, and will obſerve your Directions. —— It is a very fine Vein of Water, indeed! —— And on applying the Tube, I ſee how curiouſly it is attracted thereby; and from going ſtrait along the Room, it is bent ſo as to beſprinkle the Glaſs on the Side of it. ——— This I could ſcarcely have imagined, had I not proved the Fact.

Cleon. The Experiment to prove the Acceleration of Fluids by Electricity, will equally pleaſe you. ——— It is performed by this ſmall *Capillary Siphon*, which hangs from a ſmall Bucket of Water on the Gun-Barrel, which before it is electrified carries off the Water by a gentle Dropping only; ——— but, on the Globe's being excited, and the Water electrified, the Droping of the *Siphon* is changed into a continual Stream. ——— On applying my Finger to the Barrel, the Electricity is interrupted, and the *Siphon* again only drops. — My Finger taken away, the *Siphon* runs a Stream, and theſe alternate Operations of the *Siphon* are repeated as ſuddenly, and as often as you pleaſe.

Euphroſ. This Experiment is very wonderful indeed! And from what I ſee here, I ſhould be induced to believe, that if a Perſon was to be let Blood, and at the ſame Time electrified, it would have a conſiderable Effect upon the Stream of Blood iſſuing from his Arm.

Cleon. Indeed it would! The fine Vein of effluent Blood, as ſoon as the Perſon becomes electrified, would be accelerated, and conſequently be thrown to a greater Diſtance; and, if you chuſe it, my *Euphroſyne*, the Surgeon ſhall be called in, and the Experiment tried upon yourſelf.

Euphroſ. Indeed not I! my Curioſity is not ſo great, nor am I ſo much a Friend to Phlebotomy, as to ſuffer this Experiment: And, indeed! rather than it ſhould be tried on any Perſon, I had rather take your Word for the Truth of it, as I ſee there is ſo much Reaſon to believe; and therefore proceed to your next Experiment, and ſhew me how the Water is changed into Fire.

Cleon. This I ſhall do by the very ſame Experiment of the *Siphon* as before; only I now put to the Window-ſhutters. — The Room is made dark, and you obſerve before the Globe is moved, no Appearance of Drops from the *Siphon*; —— but the Globe being excited, you ſee a fiery Stream deſcend from the *Siphon*. ——— My Finger placed on the Barrel, the Stream diſappears. ——— When removed, the Water deſcends in the Appearance of Fire again. ——— Moreover, if I apply my Finger to the Surface of the Water in the Bucket, it yields an Eruption of Electrical Fire with the uſual Exploſion.

Euphroſ. This is a ſtrange Kind of Philoſophy, indeed! Sure no other Art could produce Fire from Water! two Elements ſo oppoſite to each other in their Nature, and yet ſo intimately connected in theſe Experiments.

Cleon. All the Works of Nature are wonderful; and what renders many of them not ſo is only their being the common Objects of our Senſes. ——— But I open the Windows again to ſhew you another Experiment. ——— You ſee here a ſmall Apparatus of three Bells, with two Clappers between them.——These will afford you a pretty Peal by Electricity.

Euphroſ. You know how fond I am of Muſic; but the Ringing of Bells by Electricity is what I have never yet ſo much as heard of. Pray, how is this effected?

Cleon. Theſe three Bells, you ſee, hang from the ſtrait Piece of braſs; the two at the Ends are ſuſpended by ſmall braſs Chains; but that in the Middle by a ſilken String. From the Center of this Bell, you obſerve, a Chain goes down to the Table; and laſtly, the two ſmall Clappers, between the Bells, are each ſuſpended by a ſilken String.

Euphroſ. This is a pretty Kind of electrified Belfry enough! and I partly ſee the Reaſon of this nice Diſpoſition of the Bells and the Clappers; for as it hangs to the Barrel, the Electricity is conducted to the two extreme Bells, by Means of the Chain. Theſe, being thoroughly electrified, will attract the Clappers, and communicate their Electricity to them: Theſe Clappers being ſuſpended by ſilken Strings, it cannot go off by them; the Conſequence of which is, they will be repelled from the outmoſt Bells, and be made to ſtrike againſt the Middle one; from whence it will run off to the Table, by the Chain which hangs from it: The Clappers, having by this Means, diſcharged their Electricity, will be again attracted by, and ſtrike the two extreme Bells, and being thus alternately attracted and repelled, they muſt neceſſarily ſtrike, and ring the Bells.

Cleon. You underſtand the Theory of this new Kind of *Campanalogia* very well; and you may obſerve, that, if there were ever ſo many of theſe Bells, theſe require but one Man to ring them all, *viz.* the Man at the Wheel; for no ſooner does he turn the Wheel, than the Clappers are all in Motion, and you hear the Muſic of the Bells. ——— If I put my Finger on the Barrel, the Clappers all ſtop at once, and you hear no more of the Sound. ——— The Moment I remove my Finger, the Clappers go, and the Bells are ringing again. ——— I put too the Window-ſhutters, and the Strokes of the Clappers are attended with Exploſions of Fire. ——— I place my Finger on the Barrel, and the Fire is no longer ſeen, nor the Sound heard. ——— Again, I take off my Finger, and the Flaſhings appear, and the Tinkling of the Bells return as before.

Euphroſ. On my Word, *Cleonicus*, if you were to ſhew theſe Experiments in ſome Countries, with a black Rod in your Hand, and a three-corner'd Cap, and a ruſty furred Gown on, they would certainly take you for a Conjurer, and believe you had the Art of dealing with the Devil, beyond even *Sydrophel* himſelf; for they could not poſſibly believe ſuch Things were to be done by the Power of Nature, as you now ſhew by this ſmall Machine.

Cleon. I don't know but what you ſay may be true enough. It is one of the miſerable Effects of Ignorance, to be amazed at every Thing that is not common, and to wonder at Nothing that is. Every wiſe Man knows, that the Powers of Nature proceed from, and are eſtabliſhed by a Being, all-powerful, and infinitely good; but ignorant People abſurdly imagine, that ſome Things are above the Power of Nature, that is, of God himſelf, and therefore muſt be performed by the Devil, and his ſuppoſed Agents here. But thoſe Notions, as they are equally abſurd, ridiculous, and impious, can only be entertained by People devoid of Reaſon on the one Hand, and pretended to by Knaves and Villains on the other. ——— But to return, I muſt ſhew you a few more Experiments to make you ſtill more acquainted with the Nature of this wonderful Power, one of which ſhall conclude the preſent Hour, and the other be deferred to another Time.

This Experiment, my *Euphroſyne*, will farther convince you, that Electricity is Fire; for it will actually kindle the Spirits of Wine, and ſet fire to Gun-powder itſelf, as well as the common Match; as you may inoffenſively be convinced of by Experiment.

Euphroſ. You ſtill talk of terrible Things. If theſe Kind of Firings are to be made by Experiment, I muſt beg of you to perform them yourſelf; it will be ſufficient for me to have Preſence of Mind enough to ſee them only; for I have no Notion of this Kind of electrical Fire-arms.

Cleon. Don't put yourſelf into any Conſternation; they cannot do any Harm to you, or me, as we have now found, by Experience, a very innocent Method of ſetting fire to the Spirit, or Powder, without ſo much as a Shock.

Euphroſ. Pray, let me know your Method of Proceedure before-hand, that I may be a little upon my Guard, in Caſe there ſhould be Occaſion.

Cleon. There have been uſually two Methods of producing this Effect: The firſt is as follows. ——— From the End of the electrified Gun-barrel, let a braſs Ball be ſuſpended by a ſmall Chain, four or five Inches long; then while the Globe is in Motion, ſome heated Spirit in a Spoon is held under the Ball, very near it; the riſing Fume is ſet on Fire by the Spark coming out of the Ball. This has been called the firing of Spirit by the *attractive Power* of Electricity. ——— The ſecond Method is, by fitting the Handle of a Spoon, or Ladle, into the hollow End of the Gun-barrel, and the heated Spirit put in, and thus electrified, and then a Perſon not electrified, applying his Finger near to the Spoon, the Spirit will be fired from the Flame ariſing from the electric Exploſion between the Spirit and Finger; and in this Caſe, it is ſaid to be fired by the *repulſive Power* of Electricity. This Method of firing Spirits is alſo otherwiſe performed thus. A Perſon ſtands on a Cake of Bees-wax, or Roſin, holding a Chain from the charged Phial in one Hand, and a Spoon with heated Spirit in the other; then any non-electric Perſon, approaching his Finger near the Fluid, ſets it on Fire as before. In the ſame Manner, if inſtead of Spirit of Wine, ſome Gun-powder be taken, and placed in the Spoon, mixed with a little Camphor, and then heated, the Fumes ariſing from the Camphor, will be fired, and communicate that Fire to the Powder, which will then flaſh away, without any Exploſion; but in theſe Methods of Accenſion, the Perſons concerned ſuffer the uſual Shock; but Experience has taught us a more eaſy Way of producing the ſame Effect, and which you yourſelf might try as inoffenſively, as you can apply your Finger to common Water.

Euphroſ. I ſhall take your Word for that; and beg to be a Spectator only in all Caſes, where Fire is concerned; as you know it to be ſo eaſy, you will oblige me with the Experiment yourſelf.

Cleon. That I will readily do, and ſhall premiſe to you one Experiment, by Way of Introduction. ——— You obſerve this Piece of Iron-wire, bent in the Form of a Curve, with a braſs Ball at each End. ——— Alſo you will remember, that I obſerved to you, the electrical Fluid, when it proceeds from the Barrel, takes a Circuit to it again, by the neareſt Way it can. —— If, therefore, I apply one Ball of the Wire to the charged Phial, the Fluid will circulate, or be conveyed thro' the Wire to the Barrel again, without touching me that holds it, the Wire being the ſhorteſt Way, ——— and the Flaſh of Light this Way, you obſerve, ſo great, as to reſemble Lightening itſelf. ——— Therefore, I take the Spoon. with the heated Spirit, and place it in the End of the Barrel. ——— Then I bring the charged Phial near to the End, and placing one Ball of the Wire againſt the Phial, and approaching the other towards the Spirit, —— you obſerve, a great Flaſh, attended with an Exploſion, which kindles the Spirit, without having the leaſt Effect on myſelf.

Euphroſ. A ſurprizing Effect this, indeed! The Exploſion was ſo fierce and loud, that it really made me leap; and innocent as it may be in itſelf, it will ſtill make me unwilling to experiment it, by Reaſon of its very ſudden and fierce Effect. ——— Pray, let me aſk you one Queſtion. Have not any of you Philoſophers thought of a Method of making this electrical Fire ſubſervient to any Purpoſes in the Art of War? For, if you could ſet Fire to Powder, as eaſy as you do to Spirits, would it not ſupply the Place of Locks to your Guns?

Cleon. The Queſtion you aſk is very pertinent; and Ways might be found, by Means of a Phial and glaſs Tube only, of diſcharging Guns and Cannon in the Field of Battle; but Nothing will prove ſo convenient as the Fire-lock and the Match: However, there is a Pleaſure in knowing what may be done, tho' it may not always be the beſt Method for Practice.

DIALOGUE VII.

The Experiments on ELECTRICITY *continued.*

Euphroſyne.

I Long'd for the Return of this Evening, when you promiſed to ſhew me the very Eſſence, as it were, of Electricity itſelf. Pray, in what Manner do you propoſe to proceed in demonſtrating this?

Cleon. For this Purpoſe, my *Euphroſyne*, it will be neceſſary, firſt of all, to make a *Vacuum*, by taking the Air from under a tall Glaſs Receiver, placed on an Air-Pump, which, you ſee, I have here provided for this Intention. On the Top of the Receiver, you obſerve, a Cork ſealed on with Wax, thro' which goes an Iron-wire, about 3 or 4 Inches below the Cork, and turned in the Form of a Ring, on the Outſide above it. To this, the Chain, which comes from the charged Phial, is hung, and conveys the Electricity to the *Vacuum* within the Glaſs, which, when the Window-ſhutters are cloſe, will be evident enough to your Sight.

Euphroſ. I am impatient to ſee this Experiment.——I have ſhut up the Windows, and made the Room dark.——The Chain is hung on the Glaſs.——And now, *Cleonicus*, let the Boy turn the Wheel, while I attend to view the Effect.——But Heavens! What do I ſee?——Not Fire of the common Sort, but ſomewhat, like Milk or Cream, deſcending in a copious Stream from the Point of the Wire.——It fills the whole Glaſs, but with a ſurprizing Kind of material Light, which I can ſcarcely call Fire.——It is quite different in Quantity, Quality, and every other Circumſtance, in which it appeared to me before.

Cleon. This plainly ſhews, that the Matter of Electricity is not that very fine, or ſubtle, ætherial Medium, as many are fond of ſuppoſing it to be.——It appears very plainly of a thick, groſs Sort of Matter, of a fluid Nature, and is rendered luminous by a *Vacuum*, and Want of common Light.——That it is the real Matter of Electricity is evident, by laying my Finger on the Barrel; for then it runs all off on myſelf, and you obſerve it no longer in the Receiver.——When I take off my Finger, it ruſhes again from the Wire into the Receiver, and fills it with a luminous Fluid.——The Light, however, is but very weak, as it is not perceptible in common Day-light.——It alſo depends upon a *Vacuum*, or Air extremely rarified; for if I let the Air into the Receiver, it makes little or no Appearance, even in the Dark, as you obſerve.

Euphroſ. All theſe Particulars I cannot but ſee with the higheſt Satisfaction, as they convey freſh Ideas to the Mind of ſuch Things as I could never otherways have known. Indeed! in this View of it, it appears of a very groſs Conſiſtence, as if it were Particles of Fire, Air, Sulphur, and other Parts of Bodies, mixed together, in one luminous Fluid. Pray, what have I further to obſerve peculiar to this Matter?

Cleon. One Thing is very extraordinary; *viz.* that, whereas all Objects appeared coloured, when viewed through a Priſm in common Light, the Light of Electricity affords no Colours at all. ——For your own Satisfaction, take this Priſm, and view it.

Euphroſ. I will. ——It appears to me no otherwiſe thro' the Priſm than without. ——I ſee nothing of any different Colours of Light, and am fully ſatisfied, as to this Particular.—— Have I any further Uſe of the Priſm?

Cleon. No; but there is another Method of ſhewing this Phænomenon ſtill in greater Perfection, by making a more perfect *Vacuum* than can be made by the Air-pump; the Apparatus of which I ſhall now proceed to deſcribe to you, having firſt opened the Windows, that you may ſee it. ——On this tall Frame of Wood, you obſerve two Cups of Glaſs, partly filled with *Mercury*, in which are immerſed the two Ends of a long incurvated Glaſs-tube, in each Part whereof, the Quickſilver riſes, above that in the Baſon, to the Height of about 30 Inches; and all the internal Part of the Tube, above the Quickſilver, is a *Vacuum*, or a Space, as void of Air, as can be made, perhaps, by Art. The Manner of making which, you will be hereafter more particularly taught; at preſent, I move the electrical Machine to the Side of the Room, under the Frame, and you will find, when it is darkened, how ſurprizingly perfect both the Matter and Motion of Electricity will appear.

Euphroſ. Then I will put the Window-ſhutters cloſe; for I long to ſee the curious Phænomenon you ſpeak of. —— The Room is now dark; therefore, haſte, *Cleonicus*, and ſhew the wondrous Spectacle.

Cleon. I am ready. ——— I lay a Wire from the Barrel to the *Mercury*, in one of the Glaſſes, which conducts the Electricity to the Tube. ——— The Globe is whirl'd round, and behold! How quick the Lightening flies from the *Mercury* into the *Vacuum* of the Tube? ——— In that, how ſtrong, how vivid, how ſenſibly, and how quick it moves through that long Space of the Tube! ——— Aſcending in one Part, running over the Top, and down the other Leg of the Tube, in an apparent Rivulet of Fire. ——— When I put my Finger on the Barrel, to intercept the Fluid, it flows no longer in the Tube. —— My Finger removed, the Torrent of Fire ruſhes on, as before, with an unequal, undulating Kind of Motion.

Euphroſ. Such a wonderful Appearance of electrical Fire, or rather of a luminous Fluid, exceeds every Thing I could have thought, or expected; the Motion of it is unſpeakably quick, and yet ſenſible at the ſame Time. I preſume, it appears thus in the Tube, as being confined in Glaſs, tranſmitted firſt from the *Mercury* on one Side to the *Vacuum*, and from thence to the *Mercury* on the other, from which it is diſſipated inſenſibly into the ſurrounding Air.

Cleon. You judge very rightly, Siſter. Nothing but a Glaſs, or other electric Tube, could confine the electric Fluid; but the Velocity of Motion in this Experiment you cannot really obſerve. That is too great to be ſenſible at the Diſtance of many Miles, as has been found by repeated Experiments made with an electrical Machine on the Top of *Shooter's-hill*, and a Chain-Conducter, ſuſpended by ſilken Strings, on the Road on either Side of the Hill, from one End to the other, more than 2 Miles. The Token was given by firing of a Gun, but the Electricity was found at the End of the Chain, as ſoon as the Light from the Fire; and, indeed, it is a Queſtion with many judicious People, if there be much Difference between the Velocity of Electricity, and that of Light itſelf; and, therefore were a Chain ſuſpended round the Globe of the Earth, the Time which the electrical Fluid would take to run through it, would probably be altogether imperceptible.

Euphroſ. Well! Theſe are unaccountable Facts to me; but does not all theſe Appearances incline People to believe, that there is a great Similitude between Electricity and Lightening? It would appear to me to be almoſt the ſame Thing; but that the Force of Lightening is ſo much ſuperior in its Effects to that of Electricity; for Lightening will kill a Man, rend Trees, and melt Metals; but I have heard Nothing more of Electricity, than of its killing a ſmall Bird, and the like.

Cleon. Becauſe you have not yet been told of the greateſt Effects of Electricity, which has killed a MAN, as effectually as a *Bird.*

Euphroſ. Indeed! Pray, how did this terrible Cataſtrophe happen?

Cleon. I will give you a ſhort Account of it. ——— After obſerving the Phænomena of Electricity, People were ſoon induced to enquire what Relation there was between that and Lightening, and to imagine, that what they had obſerved of poſitive and negative Electricity, among ſeveral Bodies on the Surface of the Earth, might likewiſe obtain, in ſome Meaſure, between the Clouds in the Heavens, *i. e.* the Clouds might be electrified ſome of them poſitively, and others negatively; ſo that thoſe which are charged with a greater Quantity of this electrical Matter would, upon meeting with others that contained a leſs, diſcharge their Overplus with ſo much Violence and Exploſion, as to cauſe the Lightening and Thunder which we ſee and hear. From hence they concluded, there was great Reaſon to ſuppoſe, that the Air was filled with this electrical Fluid, and that of Courſe, they could contrive to find by Experiment the Reality of ſuch a Thing. The flying of a Kite was looked upon as the beſt Expedient for this Purpoſe, which accordingly was tried by ſeveral Gentlemen Abroad with great Succeſs; for inſtead of holding the long Line by a Packthread, as uſual, they tied on 2 or three Yards of a ſilken String near the End, which they held in their Hands. This prevented the Electricity from coming to the Perſon who directed the Kite. At the Place where the Silk was tied on to the Hempen-cord, there deſcended ed a Packthread-ſtring, with the ſame Phial at the End of it, uſually applied to the Gun-barrel; now, by this Means, it was certain, as the Kite was a non-electric Body, and the String by which it was flown, they would certainly convey the Electricity in the Air to the Phial, which would be found by applying the Finger, or any other Object to it, as uſual. Which accordingly ſucceeded, and at ſome Times to almoſt a dangerous Degree.

Euphroſ. Well! this was carrying the Thing to a great Height indeed! The Story of *Prometheus*'s ſtealing Fire from Heaven was but a well-known Fable; but the modern Philoſophers have, it ſeems, realized it. They make nothing to deprive *Jove* of his Artillery, and that which was thought to be a Miracle in *Eliſha*'s Time, is now but the common Amuſement of the *Virtuoſi*. —— They not only call Fire from Heaven; but take it without aſking, whenever they pleaſe. ——— Such Exploits far exceed any Thing Antiquity has to boaſt of. ——— I ſhould be extremely afraid to try any of theſe celeſtial Experiments; but yet, methinks! I long to ſee ſomething of the Nature and Manner of it.

Cleon. I will take care to gratify you in this Reſpect very ſoon, by taking you to a Gentleman's Houſe, who has a proper Apparatus for that Purpoſe, and will be extremely pleaſed with an Opportunity to ſatisfy your Curioſity, in the moſt entertaining, and innocent Manner. Thro' an open Window, in the uppermoſt Room of his Houſe, a large Pole is ſuſpended on ſilken Strings within the Room, and duly balanced; ſo that a tall, iron Rod, fixed in the extreme Part without, and aſcending above the Height of the Houſe, ſhall not be able by the Force of Wind, or otherwiſe, to turn the Pole about. From the inmoſt End of this Pole, a Chain, on ſilken Strings, is carried down the Stairs to the lowermoſt Part of the Houſe, where is placed the uſual Apparatus of electrical Inſtruments. As the Iron-rod on the outmoſt End of the Pole is the higheſt Object in the Air, the electrical Fluid, when it abounds in the Clouds, and in the Air, will naturally flow to the Top of the Rod; from thence be conducted to the Apparatus below, where the Phial communicates the Electricity by a Snap. ——— Where you will ſee the Leaf-gold, and other light Bodies, attracted and repelled. ———

You will alſo hear the Bells ring on a ſudden, as if by Enchantment; and by Means of two very light Balls, ſuſpended by flaxen Threads, you will ſee his curious Method of knowing whether the Electricity is from a Cloud, electrified poſitively, or negatively: ——— And whether it be aſcending into the Air, or deſcending thence to the Earth. ——— Theſe Things may poſſibly ſalute your Eyes and Ears, at the ſame Time you are ſitting with him at the Tea-Table.

Euphroſ. Nothing would be ſo agreeable to me as ſuch a Piece of Scenery as this. ——— How poor and low muſt all vulgar Amuſements be, when compared to this!——— One would think ſuch a Gentleman would have all the World to viſit him; for my own Part, I ſhould think it an Entertainment for Angels, rather than for Men. ——— I am amazed, when I think every Gentleman of Fortune has not ſuch an Apparatus in his Houſe.

Cleon. It is not ſo much to be wondered at as you imagine. 'Tis eaſy to aſſign ſeveral Reaſons why they have not. ——— The firſt is, that every Gentleman's Houſe is not properly ſituated for this Purpoſe; for ſuch a Houſe ought to be the higheſt in the Place, or diſtant from any other. Secondly, ſuch an extraordinary Entertainment would lay him under an Obligation (as you obſerve) of having more of his Neighbours Company than he would at all Times chuſe. And laſtly, another Reaſon is, that Gentlemen of Fortune have not always the Felicity of a Philoſophical Taſte; tho' the Expence, or Trouble of erecting ſuch an Apparatus would be next to Nothing, when compared with the Sums of Money they other-ways expend to no Purpoſe. We live too late in the Day for any Enterprizes of this Kind. Had this Thing been known 50 Years ago, there had then been doubtleſs fifty of theſe Apparatuſſes to one we find now.

Euphroſ. I fear there is but too much Truth in what you ſay. ——— But I'm impatient to hear more of the Fate of that Philoſopher, whom you juſt now ſaid was killed by this Fire from Heaven. Pray, what was his Name, and how was it brought about?

Cleon. This unhappy Perſon was the ingenious and induſtrious Profeſſor *Richman*, at *Peterſburgh*, who loſt his Life by an electrical Stroke, or Shock, on the 6th of *Auguſt*, 1753, as he was obſerving, with Mr. *Sokolow*, (Engraver to the Royal Academy there) the Effects of Electricity upon his *Gnomon*, or *Electrometer*, during a Thunder-ſtorm. Mr. *Sokolow* ſaw a Globe of blue Fire, as big as his Fiſt, jump from the Rod of the Apparatus towards the Forehead of Profeſſor *Richman*, which was at that Inſtant about a Foot diſtant from the Rod. It was attended with a Report, as loud as that of a Piſtol; and he fell down inſtantly dead. His Apparatus was perfectly inſurated (or ſuſpended) by ſilken Strings, and had no Communication with the Earth; by which Means, the great Quantity of electrical Fluid, with which the Apparatus was replete, from the Vaſtneſs of the Cauſe, diſcharged itſelf thro' the Profeſſor's Body, being the neareſt non-electric Body in Contact with the Floor; and this was unfortunately the Cauſe of his Death.

Euphroſ. It chills my Blood, to hear of ſo diſaſtrous an Accident! ——Now you tell me this, I ſhall be afraid to be in the Houſe where ſuch an Apparatus is found. I muſt beg you to excuſe my Viſit to the Gentleman you propoſed. —— I am all over Horror at the Thoughts of it.

Cleon. You need not terrify yourſelf to that Degree. Such Diſaſters happen from our not being acquainted with the Force of natural Powers; but when we do know them, we can eaſily elude them. You know the old Saying *Happy are they whom other Folk's Harms make wary.* We know the Rock on which he ſplit; and, therefore, can ſteer a different Courſe, in trying theſe Experiments. We can chuſe whether we will let the Electricity go thro' our Bodies or not; we can try its utmoſt Force without feeling any of its Effects ourſelves.

Euphroſ. You have related to me ſome of the dreadful, and deadly Effects of Electricity; pray, do you know of no ſalutary, or beneficial Conſequences of its Application? I think, I have heard it mentioned as a medicinal Expedient in many Diſorders, incident to human Nature; pray, what do you know certainly of it in that Character?

Cleon. Like yourſelf, I have heard of many great Effects, and Cures performed by it. —— It has been reported, that Electricity has made the Lame to walk, the Blind to ſee, and the Deaf to hear; that it has cured Rheumatiſms, Palſies, Spaſmatic Contortions, and what not; —— but how far theſe Things have been true, I cannot take upon me to ſay, having never been an Eye-witneſs to any Cure done by it. —— There is good Reaſon, however to believe, from the undoubted Teſtimony of others, that many conſiderable Effects in Medicine and Surgery have been produced by it. * One Gentleman in particular has publiſhed a large Account of Cures performed this Way, and ſome of them very extraordinary. —— One Thing is worth obſerving, that a new Method of practiſing Phyſic, by a Kind of *electrical Inſpiration*, has proved, upon Trial, unſucceſsful, to the great Diſappointment and Mortification of the *Beau Monde*. For ſtill, alas! the Beaus and Belles are obliged to have Recourſe to the groſſer Methods of Evacuation, by Doſes, as other Folk do. And now, my *Euphroſyne*, I think, I have pretty well done with the Subject of Electricity; having ſhewn you ſuch Experiments as I judged moſt proper to give you an Idea of the Nature, and Genius of this ſtrange and ſurprizing Power. There are innumerable others, with which you may entertain yourſelf, either by reading, or practiſing of them on the Machine, as you think proper, at your Leiſure Hours: What further may be done in Electricity, muſt be left to the Diſcovery of future Experiments. In this Caſe, as in all others, People are extremely apt to run into Extremes, and pretend to a great deal more than they have any Grounds, or Reaſons for: Thus, many have vainly imagined, that the whole Solar Syſtem is kept in Motion by Electricity. —— This Fluid, they are very poſitive, is the ſame with the ſubtle Spirit which Sir *Iſaac Newton* has often mentioned; and which is mightily talked of by our modern *Virtuoſi*, and as little underſtood. —— Others make no Scruple of accounting for almoſt every Thing they ſee in Nature by it. They find an electrical Machine a much eaſier Introduction to Philoſophy than *Euclid*'s *Elements*, or the *Newtonian Principia*. —— In ſhort, they have happily found out an eaſy, and cheap Method of being wond'rous wiſe, and doing as much in half a Year, as *Newton* himſelf in half a Century. But we will leave this Species of Philoſophers to their own Deluſions, and Dotage; and, in the next Place, if it be agreeable to you, we ſhall proceed in our Speculations on other Properties of the Air, and the Deſcription of ſuch Inſtruments as are proper to explain them.

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* Mr. *Lovet*, of *Worceſter*.

DIALOGUE VIII.

Of the Nature, Conſtruction, and Uſe of the BAROMETER.

Euphroſyne.

AS I am engaged to ſpend the Evening abroad, I ſhall be glad to attend your philoſophical Explications this Morning, *Cleonicus*, if it ſuits you.

Cleon. Nothing can be more agreeable. The Morning is the prime Time of the Day for ſuch Purpoſes; but Buſineſs, which is the Baſis of Life, obliges us to apply it other-ways, and Leiſure only recommends the Evening, when ſomething ſeems wanting to recruit and exhilerate the Spirits, languiſhing with the Labour of the Day. Hence thoſe incredible Numbers we every Night obſerve crouding the Theatres of Plays, Operas, and Oratorios, for a few Hours Amuſement to the Senſes; and thoſe, generally ſpeaking, low enough too; while few attend to Leſſons on the Sciences, and the noble Reſearches of Philoſophy. ——— The Morning is fine, and we ſhall, with Pleaſure, ſee what we are about. I ſhall therefore, take this Opportunity to explain to you ſome of the moſt obſervable Properties of the Air, which yet remain to be conſidered, how far we may reduce them to Uſe in real Life, and exemplify the ſame by proper Inſtruments and Experiments.

Euphroſ. This will afford me the higheſt Pleaſure. But, what are we to begin with firſt?

Cleon. The WEIGHT *of the Air* is the moſt important Property thereof, every Way conſidered. The whole Frame, and State of Nature are intereſted in it; and particularly the Life and Health of Animals, and Plants. Then the variable HEAT and COLD of the Air will command our Regard on many Accounts; and, in the laſt Place, we ſhall find it our Intereſt to advert on the different Degrees of the MOISTURE and DRYNESS of the Air. The Weight of the Air we ſhall illuſtrate by the BAROMETER; the Heat and Cold by the THERMOMETER; and the Moiſture and Dryneſs by the HYGROMETER.

Euphroſ. In what particular Caſes does the Weight of the Air moſt affect us?

Cleon. By its very conſiderable Preſſure on the Syſtem of Animal Fibres, it gives them their proper Tenſion or Tone; or, to uſe the Phyſician's Phraſe, it braces up the Fibres to the Standard of Nature, ſo that their Actions on the Fluids are exerted with ſuch a Degree of Force, as to cauſe a due Circulation of the Fluids. In ſhort, the Weight of the Air, in the Animal Œconomy, is like the Weight of a Clock in Mechanics, which gives Motion to all the Machinery, and is the regulating Principle of the whole. Moreover, the Air, by its Preſſure, ruſhes into the Lungs of all Animals, ſets thoſe noble Ventilators to Work, communicating, by that Means, a vital Principle to the Blood, which flows through it in the freſh, and wholeſome Air that we breathe in, in conſtant Reſpiration. ——— In like Manner, we find the Air is every Way neceſſary for Vegetation; the Bodies of Plants, as well as Animals, are properly organized to circulate this neceſſary Fluid; and, by ſome Experiments, we ſhall ſee hereafter, it will appear, that they reſpire great Quantities of Air.

Euphroſ. If this be the Caſe, and our Life, as well as our Health, depends ſo entirely on the Weight of the Air, I think it behoves every one to get the beſt Information of this great Principle that he poſſibly can. Pray, what Methods do you take to make it moſt eaſily known to Mankind?

Cleon. The Experiments of the Air-Pump are beſt adapted for this Purpoſe. They ſhew the univerſal Neceſſity of this Wind; but the *Barometer* is that Inſtrument alone, which meaſures the Weight of the Air, and conſequently, will give the moſt adequate Idea thereof to your Mind. This will ſhew you its gradual Increaſe and Decreaſe of it at different Times, by which we may, in a great Meaſure, judge of the ſalubrious State of the Air; for by this, we can ſee when the Weight of the Air is greateſt, and, conſequently, moſt conducive to our Health; alſo, when it is leaſt of all, and therefore to be upon our Guard againſt any Inconveniencies that may ariſe from thence; which oftentimes affect not only our Health, but our Fortunes alſo.

Euphroſ. Pray, what do you mean by Fortunes, in Regard to the *Barometer?* Is that any Meaſure of our good or ill Succeſs in Life? Does our Riches or Poverty in any Meaſure depend on the Heavineſs or Lightneſs of the Air, *Cleonicus?*

Cleon. I can aſſure you, *my Euphroſyne*, that it is a Matter of more than meer Pleaſantry, and whether People think of it or not, it is certain, they are richer or poorer for being more or leſs prudent in their Conduct in Life; and, therefore, ſince the *Barometer* moſt certainly indicates the State of the Air, in Reſpect to its Weight, it follows, that it muſt likewiſe, at the ſame Time, ſhew us, not only the preſent Circumſtances of the *Weather*, but alſo prognoſticate the future Changes that may immediately happen; and on ſuch Fore-knowledge you will readily allow, a great deal muſt depend. If a Journey on Land be intended, a wiſe Man would conſult his Weather-glaſs; and is thereby prepared to avoid the Rain and bad Weather which might, probably, have occaſioned his catching Cold, the too general Cauſe of an ill State of Health, and oftentimes the Loſs of Life. ——— If you were to go by Sea, and there be any Hurricanes or Storms depending, the *Barometer* proves a faithful Monitor, and gives you previous Notice of the ſame. ——— Laſtly, in Regard to the Buſineſs of Huſbandry; a Perſon, poſſeſſed of a *Barometer*, knows the proper Seaſon for applying the Sickle or Scythe; when the ignorant Farmer cuts down his Corn and his Hay improvidently, and leaves them to macerate and ſpoil in the ſoaking Showers that fall.

Euphroſ. If the *Barometer* be of ſuch mighty Conſequence as you repreſent, it is ſurprizing to me, that every Man in the Kingdom has not one of them in his Houſe. Who would, for the ſake of ſuch a ſmall Sum of Money, want a general Index for Life, Health, and good Fortune?

Cleon. There are few People but what have a Weather-glaſs of one Kind or other, they are ſo ſenſible of the Benefit of it in general; but it is in this Caſe as in many others, if they get but an Inſtrument with a Name to it, and for a very little Money, they are ſatisfied; not regarding the Truth, or intrinſic Value of a good Conſtruction.

Euphroſ. By what you ſay, there are different Sorts of *Barometers*; I ſhould be glad to know how they are made, and what different Kinds of them are in Uſe.

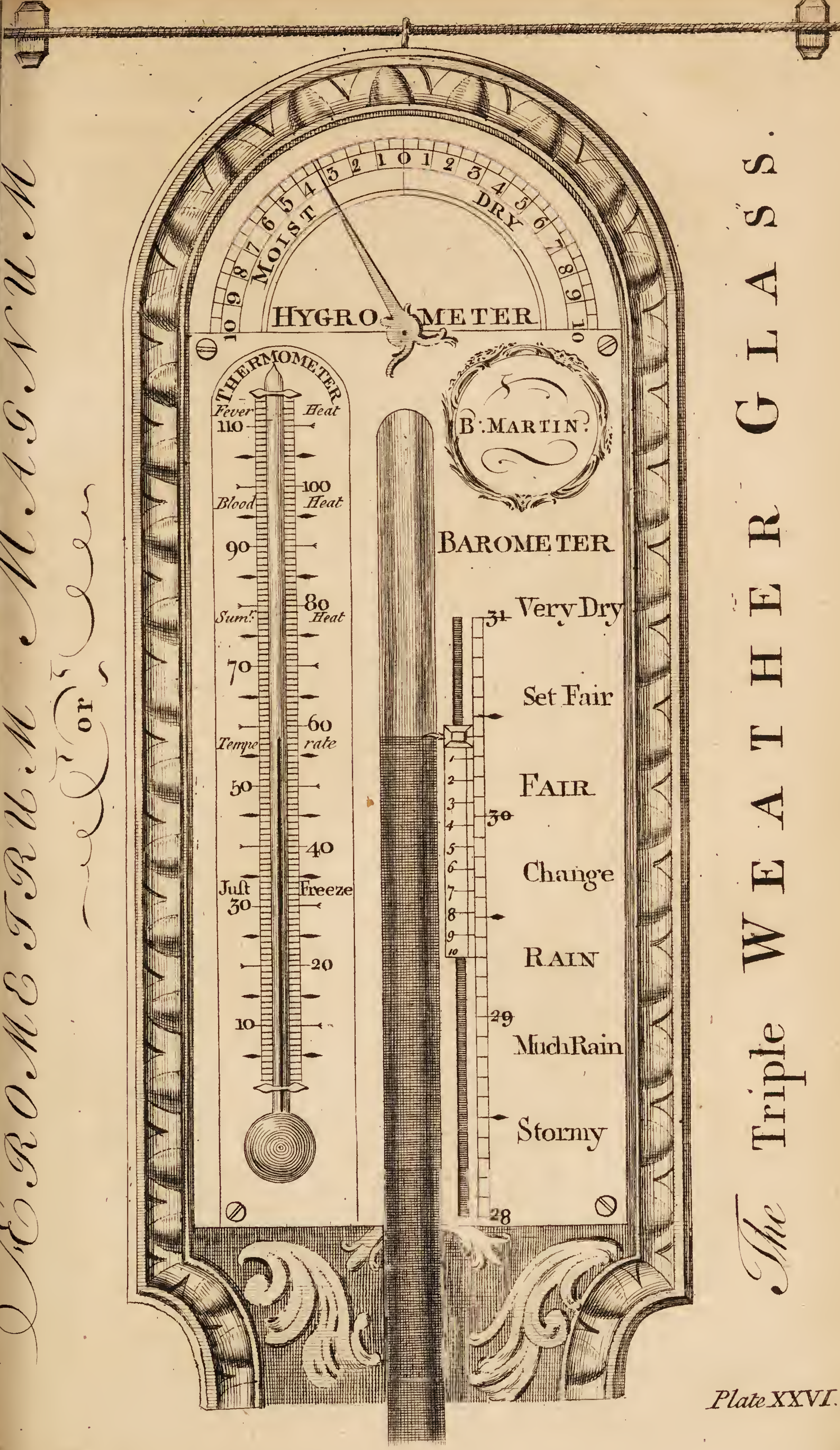
Cleon. I ſhall firſt ſhew you the Manner of making one of the beſt Sort, and then point out the Forms and Deficiencies of the Reſt. ——— I have here provided you with what we may properly call a *triple Weather-glaſs*, conſiſting of a *Barometer* of the beſt Sort, a *Thermometer*, and a *Hygrometer*, all in one Frame; by which the State of the Weather, in all the above-mentioned Reſpects, may be ſeen at one View. ——— Here it is.

Euphroſ. The Inſtrument appears not leſs elegant than uſeful: It makes a Piece of ornamental Furniture for a Gentleman's Parlour, or Study; and, I think, the moſt ſo of any one Thing I know of the Philoſophical Kind. The large Tube in the Middle is the *Barometer*, I ſee; and you may now, if you pleaſe, let me know your Method of filling it with Quick-ſilver, and likewiſe explain to me how that proves the Meaſure and the Weight of the Air.

Cleon. That I ſhall inſtantly do, in ſuch a Manner, that you, or any one elſe, may practiſe it with Pleaſure afterwards. Thus ——— the firſt Thing to be done is, to take this Phial of Mercury (which is about one Pound and a Quarter, made very pure for this Purpoſe) and to heat it by the Fire; ——— then, this Glaſs-tube, which is now empty and very clean, is to be heated by the Fire likewiſe; and then rubbed pretty briſkly with a Piece of Leather, or Cloth, juſt before the Mercury is poured in. ——— In the next Place, this little, Paper-funnel, with the ſmall Hole in it, is neceſſary to convey the Quick-ſilver in a fine Stream to the Tube, filling it by ſlow Degrees: ——— All which you ſee me now perform.

Euphroſ. And a very pretty Sight it is, to ſee the Quick-ſilver trickle down the Tube. ——— But I obſerve, as the Quick-ſilver riſes in the Tube, there are Bubbles of Air in ſeveral Parts of it left behind. Pray, how do you get them out, when the Tube is filled?

Cleon. There are ſeveral Methods by which this may be done, but the beſt is as follows ——— I continue pouring in the Quick-ſilver 'till it fills the Tube within an Inch of the Top; then ſetting



ÆROMETRUM MAGNUM or The Triple WEATHER GLASS.

Plate XXVI.

ſetting down the Phial, I apply my Finger, hard and cloſe, upon the Top of the Tube, and then invert it; by which Means, you ſee, the Air, which was on the Top, now riſing thro' all the Quick-ſilver, gathers every Bubble in its Way; then I revert the Tube, or turn it up again; the Bubble of Air now reaſcends, and if any ſmall Bubbles remain, they are now taken quite away, and the whole Body of the Quick-ſilver is left entire. ——— Look narrowly at it, and tell me if you can perceive one ſingle Bubble of Air.

Euphroſ. Not one. ——— It is quite pure, and beautifully black, like Jet. ——— Pray, what do you next?

Cleon. I take the Phial, and fill the Tube to the Top. ——— Then, I pour the Remainder of the Quick-ſilver into this Tea-diſh; and putting my Finger faſt on the Top of the Tube, I once more invert it, and put my Finger, with the End of the Tube, under the Quick-ſilver in the Cup; ——— then, withdrawing my Finger gently from the Tube, ſo that the Mercury in the Tube and Cup may readily unite, without a Particle of Air getting in. ——— And now you ſee the Silver ſubſide, or ſink down from the Top to its neceſſary Height.

Euphroſ. Very good, it does ſo. But why does it not ſink lower, *Cleonicus?*

Cleon. It can ſink no lower; becauſe the Air will ſupport ſo much in the Tube as is equal to its own Weight, upon the ſame Baſe, with that of the Quick-ſilver; for when two Fluids mutually preſs upon each other, they will always keep moving, 'till they come to an Equilibrium, or where the Weight is on each Side equal, and then they muſt neceſſarily ſuſtain each other at reſt.

Euphroſ. I remember you told me, that the Weight of the Air upon a ſquare Inch was equal to about 15 Pounds, and by this Experiment, I ſuppoſe, if the Tube was of a ſquare Form, and the Bore of it equal to a ſquare Inch, if it was filled with Quick-ſilver and inverted (like this ſmall one) in a proper Quantity of Mercury, the Mercury then would ſubſide to the ſame Height with this, and the ſquare Column, ſupported, would weigh about 15 Pounds: Am I right ſo far, *Cleonicus?*

Cleon. Very right, indeed. ——— As by this Experiment, you ſee the Weight of the Mercury in the Tube is always of an equal Weight with a Column of Air, of the ſame Baſe, and of the Height of the Atmoſphere; ſo it muſt conſequently be an adequate Meaſure, at all Times, of the Weight of the Air; and in this Manner, you ſee, the Barometer-tube is placed in the Mercury, in the Baſon at the Bottom of the Frame in the Weather-glaſs.

Euphroſ. I do. ——— But, why is it neceſſary to have ſo large a Quantity of Mercury in that Baſon?

Cleon. The Quantity is not ſo large as you imagine from its Surface. ——— It is but ſhallow, tho' the Surface be wide; for was the Surface not very large indeed, it would, in ſome Meaſure, riſe and fall with that of the Mercury in the Tube, which ought by no Means to be; for the Height of the Mercury in the Tube is always meaſured from the Surface of that in the Baſon, and therefore, unleſs the Latter was always to continue the ſame, the Variations of the Former could never be duly eſtimated.

Euphroſ. I fully comprehend your Meaning in this Reſpect. ——— What elſe is neceſſary to the Perfection of this Inſtrument?

Cleon. The Size of the Bore, which ought to be never leſs than two Tenths of an Inch, nor need it be more than four; in Tubes of a ſmall Bore, there is a ſenſible Force of Attraction from the Sides of the Tube, which prevents the free Motion of the Quick-ſilver in it, and in ſuch Caſes, no Alteration in the Weight of the Air can be ſeen, 'till it is great enough to overcome that Force of Attraction in the Tube, and therefore, thoſe Weather-glaſſes, which are made with ſmall Tubes, hold but a little Quick-ſilver, and come very cheap; but are, at the ſame Time, good for little or nothing to the Purchaſer; whereas, on the contrary, in the Tubes which are large, and will hold near a Pound of Quick-ſilver, the Weight of it will render it independent of the Attractation of the Tube; its Motion will always be free, and it will ſhew the very firſt, and moſt immediate Alteration in the Weight of the Air, and, in ſhort, no other *Barometer*, than what I have now deſcribed, will do this, and conſequently, this, as it is the moſt ſimple, ſo it is the beſt Form of any.

Euphroſ. You have convinced me very rationally, that this muſt be the beſt Form of a Barometer. But why, then, is there ſuch a Variety of other Forms of this Inſtrument, if this be the beſt of all? For I remember, upon a Viſit the other Day, I ſaw two Barometers in the Gentleman's Parlour, of a very different Form from this; one of them had three glaſs Tubes, bent almoſt horizontally towards the Top, and diſpoſed between ſeveral rich ſilvered Plates, with curious Engraving, and a charming gilt Frame; I think he ſaid, it coſt him ſix or ſeven Guineas. ——— The other, conſiſted of a very long Tube, bent at the Bottom, and turned up again to the Top of the Frame; the firſt Part, I obſerved, was filled with Quick-ſilver, the other, with a Sort of blue Liquor, but what, I don't know. ——— Pray, why do Gentlemen chuſe theſe other Forms?

Cleon. Several Reaſons may be aſſigned for it. ——— Firſt, every Gentleman that wants a Barometer cannot be ſuppoſed to know which is the beſt Form: When they apply to the Shops, they are very gravely, and *honeſtly* perſuaded to buy that Sort which the Shop-keeper has at Hand, and which his Profits are largeſt upon. ——— In the ſecond Place, they are alſo told, that the Motion of the Quick-ſilver (or other Fluid) is five or ſix Times as great in thoſe of a bent, or diagonal Form, as in the ſimple, upright one, and they immediately conclude, that they muſt be ſo much better of Courſe. ——— A third Reaſon for ſuch a bad Choice is, that many Gentlemen, as well as Ladies, affect to have Things very fine and ſhowy, and ſuch as ſhall make a grand Appearance. ——— And to mention no other Reaſons, unleſs an Inſtrument be coſtly, one Sort of Buyers will have no great Opinion of them, and the Retailer will find it, very often, a difficult Matter to diſpoſe of his Goods to theſe Sort of People, without a magnificent Price.

Euphroſ. But all you have now ſaid falls ſhort of the Satiſfaction I expected. ——— I imagine, when People buy ſuch Things, they have a greater Regard to Uſe than Decoration, and would always be fond of that which was beſt in its Kind; to which People of Fortune might annex as ſplendid an Apparatus as they pleaſe. ——— But if the Scale of Motion for the Quick-ſilver, in the compound, diagonal Barometer, be ſo great, as to amount to no leſs than 40 or 50 Inches in Length (as you hinted juſt now), and in that which you recommend the Scale is limitted to three, I profeſs I am one of them that cannot readily ſee why thoſe ſhould not be preferable to this.

Cleon. The Reaſon why you do not, is, becauſe you have not conſidered, that the principal, and critical Uſe of a Barometer is to ſhew the *firſt Alteration* in the Weight of the Air, which ought to be known for the more early and certain Prognoſtics of the Weather, and for being the more duly prepared for the Conſequences of it. ——— A Teleſcope, that would not ſhew the Moments of the Beginning or End of an Eclipſe, ought not to be called an *aſtronomical one*, or thought, by any Means, perfect in its Kind; a common Teleſcope, or a Bucket of Water, will ſerve incurious People for viewing an Eclipſe; and ſo any Sort of Barometer will ſuffice for ſhewing the Alteration of the Air, when it has already happened. The long Scale is only a vulgar Error; there are better Methods contrived to anſwer the ſame Purpoſe, in a ſimple Barometer, for ſuch as have Ingenuity enough to uſe them; I mean, a common Underſtanding only; for little more is required to be Maſters of the niceſt Parts of this Art, when we get into a right Way of thinking about it.

Euphroſ. I am not ſatisfied yet; tho' there may be great Truth in all you have ſaid. —— You have not yet told me why a Barometer of a large Scale will not ſhew the firſt Variation of the Weight of the Air, as well as this of a ſmall one.

Cleon. Well; you have brought me to the Point, and I will now declare the Reaſon to you. ——— The Mercury, in thoſe large Scales, does not reſt, or depend on the Air alone, but on the Tube in which it is contained, and the longer the diagonal, or bended Part of the Barometer is, and the greater their Number, the more will the Quick-ſilver reſt on the Tube, and the greater, of Courſe, will be the Impediment of its Motion; for it is here conſidered, as a Body moving up and down an inclined Plane, and then the Reſiſtance that is given to ſuch Bodies, conſidered mechanically, joined with what reſults from the natural Coheſion between the Quick-ſilver and Glaſs, muſt prove a conſiderable Obſtruction to its Motion; and, 'till the Weight of the Air be ſo far altered as to overcome thoſe reſiſting Forces, the Motion of the Quick-ſilver cannot begin, and therefore it muſt be conſiderably after the Time that it commences Motion in the upright, ſimple Barometer. ——— When I have ſhewn you ſome Experiments in Mechanics you will be better able to underſtand the Reaſon, and Truth of what I now tell you; at preſent it will not be worth while to ſpend more Time in ſhewing how this Principle of Reſiſtance, will ever lie as an inſuperable Obſticle to the Perfection of any other Forms of Barometers. ——— The *Wheel-Barometer* has more Ingenuity than Exactneſs to recommend it. ——— And that Barometer, which a Gentleman has lately contrived to ſhew the Height of the Mercury for every Day in the Year, deſerves very much to be admired for its Mechaniſm and Contrivance, but is too expenſive, and liable to the Objection of *Inaccuracy* with the Reſt of the *compound Form.*

Euphroſ. I ſee, you are determined to admit of no Conſtruction of this Inſtrument, but what I here have; therefore, pray, let me know how I may render this ſhort Scale equivalent to a large one, as you juſt now imply'd might be done.

Cleon. The Scale, at preſent, contains but three Inches, and each Inch is divided into ten equal Parts, which you ſee are viſible enough to the Eye; therefore, the whole Scale contains thirty viſible Parts. ——— How much further would you chuſe to go?

Euphroſ. You may depend upon it, my Curioſity will carry me as far as I can poſſibly go, in that Reſpect; and you can beſt tell me, where I muſt ſtop.

Cleon. That I will do. You may have each of theſe 30 Parts divided into 10 others, by Means of a little Sliding-piece of Braſs, whoſe Index upon the Top, points exactly to the Surface of the Quick-ſilver in the Tube; from this Index, it is divided into 10 equal Parts, which are juſt equal to 11 of thoſe on the Scale. This little Artifice goes by the Name of a *Nonius* (being the Name of the Perſon who firſt publiſhed it to the World). As 10 Diviſions on the *Nonius* exceeds 10 on the Scale by one whole Diviſion; ſo one Diviſion on the *Nonius* will exceed on the Scale by $\frac{1}{10}$; two, on the *Nonius*, will exceed two on the Scale, by $\frac{2}{10}$; three, by $\frac{3}{10}$, and ſo on; therefore, whenever you place the Index to the Surface of the Quick-ſilver, you will ſee what Diviſions on the *Nonius* and the Scale coincide, and the Number on the *Nonius* ſhews how many Parts of Ten, the Index is above the Diviſion on the Scale, next below it, and ſo will ſhew, not only how many Inches, and Tenths of an Inch, the Quick-ſilver is high, but its Height, even to the Hundredth Part of an Inch exactly; and thus the Scale is diviſible into 300 equal Parts, which is as far as the moſt ſcrupulous Philoſopher can deſire.

Euphroſ. All this may be true enough for ought I know; but unleſs you can explain it to me by an Example, you may as well tell the Story of your *Nonius* to my Linnet, as to me.

Cleon. I make no doubt but you will eaſily underſtand it by an Example or two, which you ſhall perform yourſelf, that you may be the more ready at it another Time.

Euphroſ. That pleaſes me well: ——— But, what am I to do firſt?

Cleon. Caſt your Eye on the Barometer, and move the Index of the *Nonius* nicely to the Edge of the Quick-ſilver in the Tube.

Euphroſ. This I have done. ——— What is the next Thing to be obſerved?

Cleon. Look the Diviſion on the Scale, that is next below the Index of the *Nonius*, and tell me what it is.

Euphroſ. I will look. ——— It is the ſecond Diviſion above 30; by which, I perceive, the Quick-ſilver is more than 30 Inches and $\frac{2}{10}$ of an Inch high.

Cleon. Very right; and now you are to tell me how much more, by obſerving what Diviſions of the *Nonius* and Scale coincide, which you are next to ſee.

Euphroſ. I obſerve, the fourth Diviſion upon the *Nonius* is juſt againſt the Diviſion upon the Scale. ——— But what do I learn from thence?

Cleon. From thence it is apparent, that the Index is advanced four Parts out of Ten, from the ſecond to the third Diviſion of the Scale above 30. ——— And therefore, the whole put together amounts to this, that the Quick-ſilver in the Tube ſtands at the Height of 30 Inches $\frac{2}{10}$ of an Inch, and $\frac{4}{10}$ of another; that is, 30 Inches, and 240 Parts of another Inch, is the Height of the Quick-ſilver.

Euphroſ. Very good; I ſee by this plainly, that I can determine the Height or Motion of the Quick-ſilver to the hundredth

Part of an Inch; which I am ſure will be ſufficient for my Purpoſe; and, I ſuppoſe, for any one's elſe. ——— Is there any Thing farther, in regard to Barometers, worth my Notice at this Time?

Cleon. I could obſerve to you many other Circumſtances, and Particulars, relative to Barometers, but I judge it would be Loſs of Time, at preſent, as my only View in theſe Conferences with you, is to make you acquainted with that which is beſt, and moſt perfect in its Kind, among the Inſtruments uſed in every Art or Science. We ſhall therefore diſmiſs this Subject, and proceed to conſider another Inſtrument, by which we explore the various Degrees of Heat and Cold in the Air, for the Subject of the next Leiſure-hour which occurs.

DIALOGUE IX.

Of the Nature and Uſe of THERMOMETERS, *and their Variety of different Conſtructions.*

Euphroſyne.

I Have now an Opportunity, *Cleonicus*, of putting you in Mind of your Promiſe of explaining to me the Nature of the THERMOMETER, by which you meaſure the Degrees of Heat and Cold in the Air.

Cleon. No-body is more ready to fulfil Engagements of that Kind, than myſelf, and I ſhall embrace every Opportunity for that Purpoſe; eſpecially the preſent one. The Nature of the Thermometer is, undoubtedly, reckoned among the pleaſanteſt Speculations in Philoſophy. As the Deſign of this Inſtrument is to give us an Eſtimate of the Heat or Cold in the Air at all Times, it is evident, it muſt be of the utmoſt Conſequence upon many Accounts; ſince the Health, and conſequently the Life, of Man is greatly affected by this Quality of the Air; I need not give you Inſtances of the manifold Miſeries, Diſeaſes, and other Misfortunes that have happened to Mankind in every Age, from the Intemperature, and Extremity of Heat and Cold in the Air, and therefore, we cannot be too ſufficiently inſtructed in all the proper Methods of guarding againſt them; and not only ſo, but the Vegetation of different Kinds of Plants and Trees depends upon a peculiar Degree of Warmth or Heat in the Air, Water, or Earth, in which they grow, and the *Thermometer* is found to be the principal Inſtrument for all ſuch Purpoſes.

Euphroſ. As this is the Caſe, it will undoubtedly follow, that the Ingenuity of Men of a philoſophic Turn, muſt have contriv'd and introduced many different Forms and Structures of this Inſtrument; I ſhould be glad, therefore, to know what they are, and how many?

Cleon. I muſt obſerve to you, in the firſt Place, the Rationale of the Inſtrument in general, and then recount to you ſome of the beſt Methods of conſtructing a Scale for its Uſe. ——— In the firſt Place, therefore, you are to obſerve, that every Cauſe is beſt eſtimated or meaſured by the Effects which it produces, and ſince, in moſt Bodies, the Effect of Heat is an Increaſe of their Dimenſions, therefore the variable Bulks, or Dimenſions of Bodies, will be a proper Meaſure for this Purpoſe, and thoſe, whoſe Dimenſions are moſt of all increaſed, or diminiſhed, by Heat or Cold, firſt offer themſelves as the propereſt Subjects to anſwer this End, and ſince Fluids are much more ſubject to a Dilatation and Contraction of their Bulk, than ſolid Bodies, our firſt and laſt Eſſays of this Kind have been made with them.

Euphroſ. Among the different Kinds of Fluids, which have been moſtly uſed for the Meaſures of Heat and Cold?

Cleon. The AIR is a Fluid, moſt of all apt to rarify with Heat, and be condenſed with Cold, and would ſerve for the Medium of a *Thermometer* the beſt of any Thing in Nature, were it not that the ſame Effects are produced from other different Cauſes. According to the different Gravity of the Air it will occupy a greater or leſſer Space, as well as from different Degrees of Heat and Cold, and ſo the Experiment of a *Thermometer* with Air, would become ambiguous, as it would be oftentimes doubtful, whether the Effect was owing to one, or the other Cauſe.

Euphroſ. And are there any Sort of Fluid Bodies which will be extended or contracted by Heat or Cold alone?

Cleon. Yes; every other Fluid but Air, as all others are deſtitute of a Spring, or Elaſticity, and are incompreſſable from any Weight on their Surfaces, the Alteration, therefore, that they undergo in their Bulks muſt be from Heat and Cold alone; among theſe, *Water* expands and contracts the leaſt of any, and therefore not ſo fit a Subject for a *Thermometer*; beſides, it has been lately found, that an Increaſe in the Bulk of Water will be occaſioned by a certain Degree of Cold, as well as generally by Heat, which render it ſtill more unfit for this Purpoſe. But that which moſt of all forbids the Uſe of Water in a *Thermometer* is, that it will not retain its Fluidity ſo long as is neceſſary, but freezes, congeals, or becomes fixed by a certain Degree of Cold.

Euphroſ. There are different Sorts of *Oils*, which, I preſume, may have all ſtood a Scrutiny in this Reſpect; pray, what has been the Succeſs in regard to them?

Cleon. Our *Virtuoſi* have ſucceeded greatly in their *Thermometers*, conſtructed with *Oil*, particularly Linſeed-Oil, which as it requires a much greater Heat to make it boil than Water does, or Spirits, or that which melts Wax, Tin, and Lead; but as it can be applied to no greater Degrees of Heat than thoſe, and moreover, as the Oil, by its viſcid Quality, is apt to ſtick to, and foul the Tube in which it is contained, the Oil *Thermometer* is of late but very little in Uſe, though it has been rendered very famous, as it has been rendered a Standard for Experiments on the Weather, by the great Sir *Iſaac Newton*; and they are ſtill of conſiderable Uſe, where great Degrees of Heat are not required.

Euphroſ. But is not that Fluid, which we uſually call a *Spirit*, a proper Subject for theſe Purpoſes? Do not Spirits of Wine, for Inſtance, expand and contract with Heat and Cold, and thereby anſwer the *Virtuoſo*'s Purpoſe, in a very neat and elegant Manner?

Cleon. It will do ſo, and accordingly has been, and ſtill is uſed for that Purpoſe; but ſome Objections lie againſt the Uſe of *Spirit*; as firſt, it being colourleſs it is neceſſary to tinge it with Cochineal, or ſome ſuch Matter, which, by Degrees, adhering to the Sides of the Tube, greatly ſullies it, and obſtructs the free Motion of the Spirit. Again, it can ſhew no greater Degree of

Heat than that which will make it boil, in which Reſpect it falls very ſhort of the Uſe of Oil. In the 3d Place, not only Water, and Oil, but even Spirit too, will freeze with an intenſe Degree of Cold; beſide ſome other Imperfections in a Spirit-*Thermometer* that might be mentioned.

Euphroſ. Why then if neither *Water*, *Oil*, or *Spirit*, will anſwer the Philoſopher's Purpoſe, I ſuppoſe we ſhall be obliged to have recourſe at laſt to *Quick-ſilver*; for I can think of nothing elſe; and I obſerve, it is what you have in the *Thermometer* of your *Triple Weather-glaſs*; which, as it is deſigned for your own Uſe, I preſume, you think the beſt of all others.

Cleon. It generally is the beſt for all the Purpoſes of meaſuring Heat and Cold, the Quick-ſilver being very dilatable with Heat, and the Attraction between the Particles of Quick-ſilver being much greater than thoſe of Glaſs, is the Reaſon why it will move extremely free with Heat and Cold; to which we may add the Purity, and higheſt Degree of Fluidity in this Subſtance above any other; though even a mercurial *Thermometer* ſimply, and alone, will not anſwer every End propoſed by thoſe who are very curious.

Euphroſ. Pray, *Cleonicus*, in what Reſpect is it deficient?

Cleon. In one material Point, *viz.* though it really ſhews the greateſt Degree of Heat and Cold that happens; yet, as the Spectator's Eye is not always upon the Tube, he may not be appriſed what thoſe greateſt Degrees of Heat and Cold were; therefore, may remain ignorant of a Thing he may greatly wiſh to know.

Euphroſ. And have you no Remedy, no Invention, for this Purpoſe at Hand? I think it is Pity if there be not; becauſe it is a Point of ſuch Curioſity, as even I myſelf, though a *Woman*, ſhould be glad to be ſatisfied in.

Cleon. The World, till very lately, has had no Opportunity of obſerving thoſe nice Particulars. It was ſomewhat ſurpriſing, that ſo many learned, and curious Gentlemen, who lived in the laſt Age, ſhould not think of, and communicate a Method for this Purpoſe. I do not remember in my Reading, it was ever ſo much as mentioned in their Writings; but, at Length, we are happily poſſeſſed with an Invention that fully anſwers theſe Purpoſes. The attentive Philoſopher can now readily obſerve

ſerve the Meaſure of the greateſt Degree of Heat and Cold, as well as of any other: This we receive too from the Hands of a Nobleman, of which curious Contrivance I ſhall give you a more particular Account by-and-by, when I have more fully informed you of the Uſes to be made of the more common *Thermometers.*

Euphroſ. Well! I ſhall detain you ſome Time on this Subject, as I have many Queſtions to aſk of the Uſes of that pretty, little Inſtrument; and, in the firſt Place, why are the Bores of thoſe Tubes made ſo extremely ſmall? For unleſs my Eyes were good, I ſhould ſcarce perceive the Vein of Quick-ſilver in them.

Cleon. You will readily conceive the Reaſon of this even before I mention it, if you did but advert, that the ſame Quantity of a Fluid will paſs through a greater Length in a ſmall Tube than in a large One; by which Means, the Diviſions, which meaſure this Space in the Scale, become larger, and conſequently more eaſily obſerved; for unleſs the Quantity of Quick-ſilver, and therefore the Bulb of the Tube be large, this Space, thro' which it moved in the Bore of the Tube, would not be conſiderable, unleſs that Bore was very ſmall.

Euphroſ. I am afraid you will think me impertinent, if I ſhould aſk you how they get the Quick-ſilver thro' ſuch a ſmall Bore into the Bulb of the Tube.

Cleon. Not at all ſo; for I like to hear People inquiſitive about the Manner of doing Things: that when I obſerve a Perſon viewing any Thing, in its own Nature very curious, and, at the ſame Time, ſeem not concerned to know how it be done, I always take it for granted there is Want of Genius. ——— Not that I can pretend to inform you of the whole Proceſs; in this Caſe it will be ſufficient to mention two Particulars; the firſt is, that they drive the Air out of the Tube with the Flame of a Lamp, and when the Air is gone, any thing Fluid will eaſily run into it, and therefore the Mercury, from a Paper-funnel placed over the Top of the Tube. 2dly, In order that the Mercury may be as pure as poſſible, it is firſt made to boil, and then poured in, not only very pure, but likewiſe free from Air, and ſo it will always remain, and by that Means become fit for Uſe.

Euphroſ. You will now indulge me with an Account of the particular Uſes of the *Thermometer*; for though I know ſomewhat of them, yet I would be glad to be ſtill more perfectly informed.

Cleon. I need not tell you, in general, that the Deſign of a *Thermometer* is to meaſure the different Degrees of Heat and Cold in the Air, or to ſhew its various Temperature in thoſe Reſpects; this always proves a Pleaſure, as well as a Curioſity to inquiſitive Minds, eſpecially as we can exactly ſee it meaſured by the Diviſions of the Scale, much better than we can be acquainted with it from any of our common Senſes.

Euphroſ. But I obſerved, from what I heard a young Phyſician ſay not long ſince, that they muſt be of conſiderable Uſe in Medicine; for he was obſerving to the Company, that they were the beſt Index of the Heat of the human Body, and that in a feveriſh State he could form his Prognoſtics more certainly by that Inſtrument, than any other Way.

Cleon. No doubt of it; as the *Thermometer*, placed in the Hand, in the Mouth, or under the Arm-pit, and there held for the Space of a Minute, will undoubtedly diſcover the Degree of Heat in ſuch a Body; by which it will be eaſy to underſtand if it has a Tendency to be feveriſh, and how far it is ſo; for which Purpoſe the ſeveral Degrees of Heat are marked upon the *Thermometer*, as you here ſee; and it would be worth the Phyſicians while to obſerve every Degree of Heat, from the leaſt to the higheſt, in a Fever, and to have a Scale, properly divided by ſuch Experiments, for the Uſe of the Faculty, and of Mankind in general: We have them in a common Way already, but not with that Accuracy as could be wiſhed. In *Farenheit's Thermometer*, which you ſee here, the freezing Point is marked at 32, a Temperate-heat at 55, the Summer-heat at 75, the Heat of the Blood at 95, and a Fever-heat at 110; but then theſe Things are all in a vague, and general Way; and, indeed, it would be a very difficult Matter to aſcertain them in ſo accurate a Manner as could be wiſhed.

Euphroſ. As there are all Degrees of Compariſon, and relative to one particular Standard-ſtate of Heat, ſhould not that be firſt of all fixed upon and determined?

Cleon. Undoubtedly; it ought to be ſo, if one knew which Way to do it; for this intermediate, or Standard-diviſion, which ought to ſhew what we call the Temperate-ſtate, or Boundary between Heat and Cold, is, in itſelf, an uncertain Thing.—— And if we conſider it as a Mean between two Extremes of Heat and Cold, then thoſe Extremes ought, in the firſt Place, to be determined and fixed before the Mean or Temporate-point can be determined. If we make the two Extremes, 30 for Freezing, and 80 for the greateſt Summer's-heat, in general, then the Difference being 50, Half that, *viz.* 25, added to the leſſer Extreme 30, gives 55 for the Mean, or Temperate-point, as you ſee it in *Farenheit's Thermometer*; but if one Extreme be a Fever-heat, or Boiling-water, and the other the greateſt Degree of Cold, they will give a different Point in the Scale for a Mean between; from whence it is manifeſt, that no certain Rule can be given, for the Determination of the Mean, or Temperate-point, from any Thing hitherto diſcovered by Experiment.

Euphroſ. Then we will ſuppoſe it to remain where it is at 35 Degrees. ——— I further obſerve, the utmoſt Extent of your Scale is at Boiling-water, marked 212. Is it not neceſſary, ſometimes, to experiment Degrees of Heat beyond that?

Cleon. Yes, very often; but then we are provided with *Thermometers* of a larger Bore; for the Heat of melted Lead, and Tin, is much greater than that of Boiling-water; and the Heat of a Coal-fire, twice as great as that; and the Heat of Wood-fire, greateſt of all; which, therefore, would occaſion the Motion of the Quick-ſilver through a very large Space, were not the Bore of the Tube made proportionably large.

Euphroſ. But how could you poſſibly try ſuch Degrees of Heat with a Glaſs *Thermometer?* You cannot put that into melted Metal or Fire, ſurely.

Cleon. We certainly can, and do very often, tho' it may ſeem a Wonder; for Glaſs will endure any Degree of Heat, without breaking, if there be no Air confined within, and the Quick-ſilver ſhews any Degree of Heat, till it boils; which even a Wood-fire will not immediately occaſion. To convince you of this, I will ſhew you one Experiment. ——— You ſee here a Spirit-lamp, burning with a clear Flame. ——— I take the *Thermometer* off from the Plate, and hold the Bulb about an Inch above the Flame. ——— You inſtantly ſee the Quick-ſilver riſing up very faſt. ——— I bring it nearer the Flame, and you ſee it up half Way the Tube. ——— I now place the Bulb in the Body of the Flame, and the Heat of the Fire cauſes it to riſe to the Top of the Tube. ——— Were it continued there but a little Time, the Quick-ſilver would boil, and fly out of the Tube.

Euphroſ. This is a moſt curious Experiment, indeed, and a fine, large Inſtrument, I ſee, you have provided for this Purpoſe; by which you can experiment all Degrees of Heat, to that of Fire itſelf, and it is wonderful indeed. To what other Uſes are *Thermometers* applied?

Cleon. To one of great Importance to Botaniſts, and thoſe Gentlemen who are curious in the Culture of Exotic Plants; and thence it is, we ſee thoſe Inſtruments ſo common in Stoves, Green-houſes, and Botanical-gardens, to regulate, and determine the Degrees of Heat neceſſary for each reſpective Species of Plants; for as thoſe of Foreign Extraction are brought from different Countries, the Degrees of native Heat, or that peculiar to their Climes, muſt be imitated, as near as poſſible, in the Hot-houſe, and Hot-beds, which alone can be done by a Botanical *Thermometer*; in which you will obſerve, thoſe Foreign Plants require thoſe ſeveral Degrees of Heat againſt which they are placed; for I have provided one on Purpoſe here to ſhew you.

Euphroſ. This is an elegant Inſtrument as well as uſeful; I ſuppoſe it is moreover applicable to the Purpoſes of the Kitchen-garden, in the Hot-beds on which we plant Cucumbers, Melons, *&c.* in regulating the Degrees of Heat under thoſe large Glaſſes, which are placed over many different Kinds of Plants, by Gardeners, to forward their Vegetation and Maturity.

Cleon. Theſe are the Purpoſes to which they are commonly applied, to force, rather than to forward Nature; if it were not the Faſhion to have preternatural Diet, we ſhould not obſerve their Uſe ſo frequent in our Kitchen-gardens; but when our Quality make it neceſſary for us to tranſgreſs the Rules of natural Beauty and Order, we have the Honour of eating the choiceſt Products of the Garden premature, and without their natural,

ral, agreeable, and wholeſome Reliſh, which People of lower Life muſt only expect or pretend to.

Euphroſ. Well! Thanks to my Stars, I am not ſo high bred; I am willing to wait the proper Times and Seaſons appointed by Nature for theſe Things. The *Aſparagus*, *Cucumbers*, *Peaſe*, &c. in their natural Perfection, and trueſt Reliſh, amply reward my Patience, in pleaſing my Palate to the higheſt Degree. It was not long ſince I was in a Gentleman's Garden, and tried an Experiment of this Kind. A flouriſhing Vine was growing at the Side of a Hot-houſe, and one Branch thereof was taken into the ſaid Houſe, and foſtered with its unnatural Degree of Heat; the Conſequence was, that large Cluſters of Grapes were ſeen hanging on that Branch, when on all the Vine without, expoſed to the Coldneſs of its native Clime, the Bloſſoms had but juſt diſappeared: I was bid to taſte, by the Gentleman, of his Grapes, that I might ſee how far it was in the Power of Art to aſſiſt Nature in her Productions. I did ſo; but found them far ſhort of that charming Flavour, which thoſe Grapes have, preſented by *Nature*'s own Hand, and in her own Time. But to put an End to this Digreſſion; pray, what other Uſes are made of theſe Inſtruments?

Cleon. They are of excellent Uſe in philoſophical Chemiſtry; in diſcovering the ſeveral Degrees of Heat which ariſe upon the Mixtures of different Kinds of Fluids, and Fermentations, conſequent thereupon; they will diſcover great Degrees of Heat, where otherwiſe none at all would be ſuſpected. Thus, for Inſtance, a little Oil of Vitrol, poured into a Tumbler of Water, ſhews, by the *Thermometer* placed in it, a conſiderable Degree of Heat occaſioned thereby, when no Commotion of the compound Fluid appears to the naked Eye. The *Thermometer* is likewiſe of great Uſe in Sand-heats, frequently made Uſe of for Digeſtions, Solutions, Concoctions, &c. for regulating the requiſite Degrees of Heat therein; they might, likewiſe, be applied to *Papin*'s *Digeſter*, which cannot be looked upon as perfect without it; but, with it, may be made to anſwer many more curious, and important Purpoſes than hitherto it has done.

Euphroſ. I ſee in one Frame you have two *Thermometers*, which you call the Standard-*Thermometers* of *Newton* and *Farenheit*;

heit; pray, how do they differ from each other, and why have you of both Sorts? For I obſerve one is filled with Oil, and the other with Mercury, and their Diviſions are different one from the other.*

Cleon. I will explain to you the Nature of the firſt, *viz.* Sir *Iſaac Newton*'s, which is the original Standard of all others, and then you will the better ſee the Difference between that and the other. Sir *Iſaac*, in this, as in all other Caſes, had a ſingular Method of compleating his Deſign; he contrived to fill his Tube with Oil in ſuch a Manner as to be certain of its Bulk to $\frac{1}{1000}$ Part of the Whole, and the Diviſions, or Numbers which you ſee on the Left-hand Side, expreſs the Expanſion, or increaſed Bulk of the Oil in thoſe Thouſandths Parts; thus for Inſtance, he divides that Bulk of Oil, which it has when Water begins to freeze, into juſt 1000 equal Parts, as you ſee marked againſt that Number in the Scale; after this, any Degree of Heat expands it ſtill more which are meaſured and expreſſed by the other Numbers of the Scale above, till at laſt you come to the Degree of Boiling-water, which expands the Bulk of the Oil to 1074 of thoſe Parts; all which, I preſume, you apprehend very eaſily, from a bare View of the Inſtrument.

Euphroſ. I do, very well; but, what are thoſe Numbers I obſerve on the Right-hand Side of the Tube; having a Cypher, or 0 placed at the Boiling-water, and increaſing upwards, and downwards, by the Intervals of 6 Diviſions?

Cleon. By theſe, Sir *Iſaac* expreſſed the comparative Degrees, or rather Differences of Heat, for any given Quantities of its Bulk. Thus 6 Degrees of Heat above that of Boiling-water, expand the Oil 13 Parts of 1000, or raiſe it to the Number of 1013, and ſo on all the Way up the Scale; likewiſe, the ſame Difference of 6 Degrees below the Point of freezing contracts the Bulk of the Oil, or makes it ſtand only at 987 in the Scale.

Euphroſ. This I likewiſe clearly apprehend. But how comes *Farenheit*'s *Thermometer* to be reckoned a ſecond Standard?

Cleon. After mercurial *Thermometers* were found to be beſt, it was thought proper to have one of this Kind made from the *Newtonian* Standard, and that of *Farenheit*'s being moſt in common Uſe, it was pitched upon for this Purpoſe, as it were, by the

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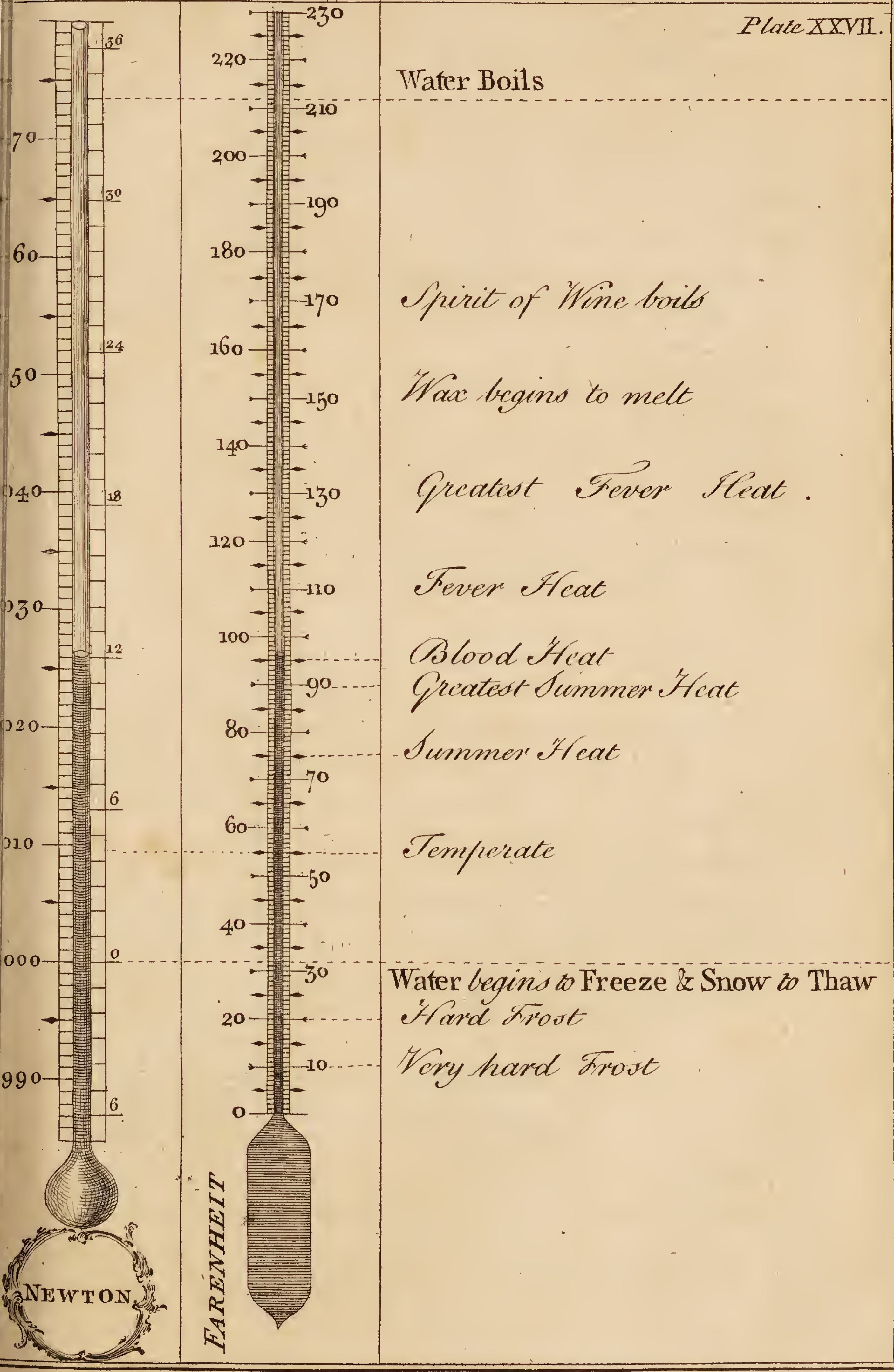
* See Plate XXVII.

The Standard THERMOMETERS *of* NEWTON & FARENHEIT.

Plate XXVII.



the general Conſent of the Public, tho' the Diviſions upon it are entirely arbitrary, and not the beſt, by much, that might have been choſe for this Purpoſe; but it is in vain to oppoſe any Thing that is eſtabliſhed by a general Uſe, or Cuſtom, tho' in itſelf ever ſo inartificial, or abſurd.

Euphroſ. Then Philoſophy itſelf is ſubject to the ſame Inconveniencies, as many other Sciences, and Profeſſions; and if Philoſophy cannot mend the World, and reduce Mankind to Reaſon, I know not what will; according to the Proverb *There is no general Rule without an Exception.* I ſuppoſe every Body will not blindly follow *Farenheit* in the Diviſion of their *Thermometer* Scale.

Cleon. They do not; for ſeveral Societies and great Philoſophers have choſe other Methods; of which the late Dr. *George Martin* has given an Account of a great Number, in his Treatiſe on this Subject; but ſtill, thoſe who are curious, and would communicate their Obſervations to the Public, are neceſſitated to have Recourſe to the above-mentioned Scale. And thus much may ſuffice, for the preſent, for the Nature and Uſe of Simple *Thermometers.*

Euphroſ. By this you imply, there are Compound *Thermometers*, as well as *Barometers.*

Cleon. There are ſuch, and made of the ſame Materials too, nearly, *viz.* Quick-ſilver and Spirit put together in an inverted Tube; by which Means the Scale of Motion in the Quickſilver is enlarged, and therefore, the Bore of the Tube is not required to be ſo very ſmall; hence, Obſervations are more eaſily made by the Compound than by the Simple *Thermometer.*

Euphroſ. This, one would think, muſt be a conſiderable Improvement of this Inſtrument; I ſhall be obliged to you, if you would explain the Reaſon of its Operation more plainly than I yet apprehend it.

Cleon. This I ſhall do, by preſenting you with a View of the Inſtrument in two different Forms. In the firſt, the Tube is bent but once, and in the other, twice; as you ſee by the Specimens I here preſent you. You obſerve, one Part of the Tube is large, and filled with Spirits, and the ſmaller and longer Part contains Quick-ſilver. The larger Part, which holds the Spirit, is ſometimes of a globular, and ſometimes of a

cylin-

cylindric Form; which latter is moſt convenient, becauſe in that, the Heat can more immediately affect, and dilate the Spirit; and becauſe the Spirit, with the ſame Degree of Heat, will be expanded much more readily than Mercury, and may be more conveniently contained in a much larger Quantity, it will, as I ſaid before, by its Expanſion, cauſe a greater Motion of the Quick-ſilver, and therefore, admit of a larger and more convenient Scale. The ſame Thing may be ſaid for the other, in the ſecond Form; but the noble Author of this Invention had another Point in view, which was, to ſhew the Meaſure of the greateſt Heat and Cold that ſhould happen in the Courſe of the Year, by the peculiar Conſtruction and Mechaniſm of theſe Inſtruments.

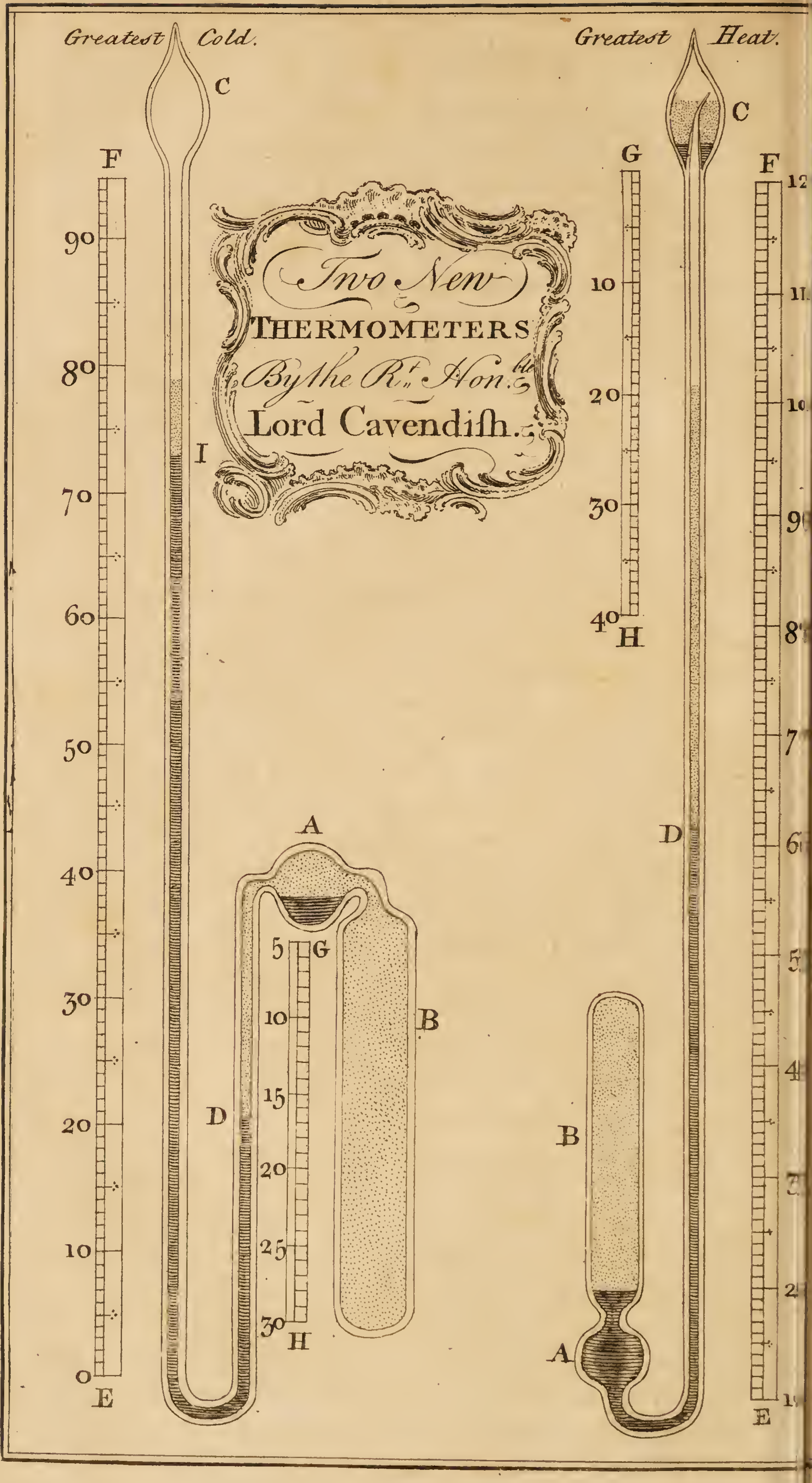
Euphroſ. I believe what you now mean relates to the Bulb, which I ſee on the Top of the Tube of the firſt Form, in which I obſerve a ſmall Quantity of a Fluid, and a very fine Piece of Glaſs ſtanding up in the Middle of it, and inclining, towards the Top, to one Side of the Bulb; but what the Uſe and Intent of all this is, I am not able to conceive.

Cleon. In this very Part, as you rightly obſerve, conſiſts the critical Uſe of this Inſtrument. That fine Piece of Glaſs, as you call it, is only a very fine, capillary Tube, which the Upper-end of the long Tube is drawn into by the Art of the Glaſs-man; over this fine Part, he has dextrouſly fixed that hollow, glaſs Bulb, with which the Tube, by Means of the fine, capillary Part, communicates; for that, you muſt know, ſmall as it is, is hollow throughout.

Euphroſ. Well; that is more than I ſhould have miſtruſted; I can ſee no Hollowneſs in it; but ſuppoſing that, what is the Uſe of the Fluid, that I ſee in the Bulb, and in the Tube below it?

Cleon. You will underſtand, my *Euphroſyne*, that after the proper Quantity of Spirit and Quick-ſilver is put into the Body of the Tube, then the remaining Space above the Quick-ſilver is filled with a ſmall Quantity of the ſame Spirit; then the Tube being drawn out, on the Top, to a capillary Form, and the Bulb fixed over it, it muſt follow, that when the Quick-ſilver riſes in the Tube, by the Expanſion of the large Body of Spirit, then that Spirit above the Quick-ſilver in the Tube will neceſſarily be driven thro' the fine, capillary Part,

Plate , XXV


Greatest Cold.
Greatest Heat.
Two New
THERMOMETERS
By the Rt. Honble
Lord Cavendiſh.
C
F
90
80
70
60
50
40
30
20
10
0
E
I
D
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G
5
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15
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25
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H
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E

Part, into the Bulb, and falling to the Bottom cannot poſſibly return; therefore, a Vacancy will be left between the Quick-ſilver and the Spirit above it in the Tube; and this will be greater in Proportion, as the Quick-ſilver has riſen higher in the Tube, and therefore, ſince the greateſt Degree of Heat will cauſe the greateſt Vacancy, between the Quick-ſilver and Spirit, it will plainly ſhew the higheſt Elevation of the Quick-ſilver that has happened during the Abſence of the Obſerver.

Euphroſ. Can you explain this to me by an Example?

Cleon. Yes; I have provided two *Thermometers* for that Purpoſe; the firſt of which, you ſee, in this Frame, with two Scales, E F G H, one large, and the other ſmall; the firſt meaſures the Riſe of the Quick-ſilver at D, by the Expanſion of the Spirits, in the Part B: The Second, G H, meaſures the Vacancy in the Tube above between the Bulb and the Spirit, by which, at any Time, it may be known how high the Quick-ſilver has riſen in the Tube, ſince it was rectified for Obſervation.

Euphroſ. What do you mean by rectifying this *Thermometer?*

Cleon. I will ſhew you by Experiment what I mean. ——— You ſee here a Spirit-lamp, the Flame of which I bring near to the Spirit at B, which, being expanded by the Heat, will raiſe the Quick-ſilver towards the upper Part of the Tube, which will drive the Spirit there, thro' the capillary Part, into the Bulb at C. ——— Then you obſerve, that I hold the Inſtrument very much inclined, ſo that the Spirit may always cover the capillary End. ——— Then I remove the Lamp, and let the Tube remain in that Poſition, 'till the Spirit, at B, cools, or gets to be of the common Temperature of the Air; then will the Quick-ſilver ſubſide, and the Spirit, from the Bulb C, fill all the upper Part of the Tube above.

Euphroſ. This I ſee is the Caſe; and what am I to learn from hence?

Cleon. You obſerve, the preſent Temperature of the Air is ſuch, as makes the Quick-ſilves ſtand at 60 Degrees; ſuppoſe you obſerve it no more 'till To-morrow at this Time, and then you ſee the Spirit at the Top ſtand 19 Diviſions below the Bulb in the Scale, G H; that will ſhew, that ſo many Diviſions is to be added to the Height of the Quick-ſilver where you then ſee it, and that will give the greateſt Height (*viz.* 89th Diviſion) to which it has riſen in the mean Time; and thus you may proceed, by refitting the Inſtrument for any other Time. One Thing you may obſerve, and that is, that the Spirit above the Quick-ſilver will be expanded by Heat, and therefore, occaſion a ſmall Degree of Irregularity in this Inſtrument. But as it amounts to no more than about a 6th Part in a Riſe of Ten, it will not be worth regarding in common Uſe.

Euphroſ. I underſtand the Deſign of this Inſtrument perfectly well: But, what is this other crooked Inſtrument in the Frame, which ſeems of a more complicated Structure than the Former.

Cleon. There is not much Difference, if you will obſerve; it conſiſts only in this, that the Ball A, in the Former, was in a vertical Poſition, and the Cylinder, B, pointed upwards; whereas, in the Latter, the Ball, A, is in a horizontal Poſition, and the Part B is turned downwards.

Euphroſ. The Rationale of this Contrivance, I preſume, I ſhall underſtand when you have explained it.

Cleon. You will, very eaſily; having firſt obſerved, that there is a Communication between the Cylinder, B, the Ball, A, and the Syphon of the *Thermometer*; ſo that, when the *Thermometer* is filled with Quick-ſilver, and Part of the Ball, A, the Spirit from B fills the other Part, and in this Caſe, it will be fixed in an upright Poſition for Obſervation; then it will follow, that, if the Weather becomes colder, the Spirit, in B, will be contracted, and more of the Quick-ſilver will diſtil from the *Thermometer* into the Ball, A; after which, when the Weather becomes warmer, the Spirit, in B, will expand, and cauſe the Quick-ſilver, of Courſe, to retreat from the Ball, A, in the ſhorter Leg, to D; the Diſtance of which is meaſured in the ſhort Scale, G H, which Number of Diviſions there is to be ſubtracted from that Number at which the Mercury ſtands, at I, in the longer Leg. Thus, for Inſtance, ſuppoſe that the Quick-ſilver, at D, be 17 Degrees below the Center of the Ball, A, and that the Mercury, in the longer Leg, at I, ſtands againſt 75, then from 75 you deduct 17, and there will remain 58, to which the Quick-ſilver has ſubſided with the greateſt Degree of Cold that has happened ſince the Inſtrument was fitted for Uſe: And thus, by filling the ſhorter Leg with Quick-ſilver, from the Ball A, which is done by reclining the Inſtrument 'till the Mercury in the Ball, A, lies over the Orifice of the Tube, then the Spirit, in B, being a little heated, will drive it into the Tube by Degrees, 'till it is filled to the Top, and united with that in the Ball; in this Poſition it muſt remain 'till the Spirits become cold, and then it is fitted again for Obſervation; and if, in the Beginning of the Winter, it be in this Manner prepared, it will ſhew the greateſt Degree of Cold that has happened during the whole Winter, by the greateſt Length of Spirit in the ſhorter Leg, meaſured in the Scale G H. There are ſeveral other minute Particulars relating to this Inſtrument; which, if you chuſe to be farther ſatisfied about, you may, at your Leiſure, conſult the 38th Number of the *Philoſophical Tranſactions*, Vol. I. Part I. for the Year 1757.

DIALOGUE X.

Of the Nature and Uſe of HYGROMETERS.

Euphroſyne.

BESIDES the *Barometer* and *Thermometer*, you mentioned another Inſtrument uſed in philoſophical Enquiries, which you called an *Hygrometer*; pray, is it of Moment enough to require any of your Time in the Deſcription thereof?

Cleon. It is not to be expected, that every Thing ſhould be of equal Uſe and Concernment; and ſince theſe Inſtruments are deſigned to ſhew the Moiſture and Dryneſs of the Air, they cannot be ſuppoſed unworthy the Obſervations either of a Philoſopher, or a prudent Man; for we find, by Experience, that moſt Things are affected by the Moiſture and Dryneſs of the Air, and particularly the Animal Œconomy, the Cauſes of the minuteſt Variations in which it is of the utmoſt Conſequence to explore; as a dry Air, whether hot or cold, is always healthy, ſo a moiſt, or damp Air, is well known to be productive of many Diſorders to Mankind, as Colds, Rheumatiſms, Pains in the Joints, and many other dangerous Diſeaſes; an Index, therefore, to ſhew, conſtantly, the different State of the Air, in a Room where we uſually ſit, muſt be conſidered as one Thing neceſſary towards the Preſervation of our Health; and we cannot be too well prepared againſt the Attacks of ſo great a Number of Diſorders that we are liable to from every Quarter.

Euphroſ. What are the Forms of thoſe Kinds of Inſtruments, and which would you recommend as the beſt?

Cleon. Many are the Contrivances, and the different Forms of thoſe Inſtruments, which the Ingenuity of Men have contrived, and alſo, the Materials of which they have been made, which depend, in general, upon three different Principles, *viz.* firſt, the Expanſion, or Contraction of Bodies, by Moiſture and Dryneſs; ſecondly, the Increaſe, or Decreaſe of Weight, from the ſame Cauſes; thirdly, the different Motions of the ſame Body occaſioned by thoſe different Qualities of the Air.

Euphroſ. Will you be ſo good, as to illuſtrate theſe Things, *Cleonicus*, by Examples?

Cleon. Every Plank, or Board becomes an *Hygrometer*, by expanding or contracting with Moiſture and Dryneſs; which you ſee very often in the Pannels of the Wainſcot, the Doors of the Room, *&c.* are found narrower and wider, as the Air is more or leſs dry; particularly in Fir, the moiſt Particles of Air inſinuating into the Pores of this Wood will cauſe a conſiderable Increaſe of its Dimenſions, laterally or Sideways; and therefore, if ſeveral Pieces of a Deal-board were ſawn off a-croſs the Grain, of about an Inch wide, and then glewed together by their Ends, they would, by this Means, make a very convenient *Hygrometer*; as the Difference would, by this Means, become very different, and eaſily variable, by Moiſture and Dryneſs; and ſuch a compound, lignous *Hygrometer* might, in many Caſes, anſwer very good Purpoſes.

Euphroſ. This is a very natural, and curious Contrivance; and, pray, what Forms ariſe from your ſecond Principle, the Increaſe of Weight?

Cleon. You will eaſily apprehend, that any Body, of a ſpungy Subſtance, will naturally attract and imbibe the moiſt Particles of the Air, and thereby, of Courſe, become heavier. Hence, then, if a fine Balance, or Stilyard be provided with a large Piece of Spunge, hanging at one End, and equipoized at the other, in a Middle State of the Air; and then if the Slyte, or Cock of the Balance, be made to move over a graduated Circle, as the Spunge became heavier, or lighter, by Moiſture and Dryneſs, it will be ſhewn by the Degrees, on one Side or the other of that middle Point; and to keep this Equipoize, in different Weights of the Air, a fine Chain is uſually fixed to the Bottom of the Balance, Part of which is ſupported by a Stand for that Purpoſe; and as the Scale, or Beam of the Stilyard riſes higher or lower, ſo the greater or leſſer Quantity of this Chain will conſtantly preſerve the variable Equilibrium. But in making *Hygrometers* of this Kind, the Piece of Spunge ſhould be firſt prepared by dipping it in a Solution of Salt of Tartar, *Sal Armoniac*, *&c.* and then dried again; for by this Means, the Spunge becomes impregnated with Salts, which attract more readily a larger Quantity of Moiſture in the Air; alſo thoſe ſpungy Bodies ſhould be very thin, in order to have as much Surface expoſed to the Air as poſſible, by which Means the Variation will be the more eaſily diſcovered.

Euphroſ. And what Sort of *Hygrometers* are derived from your third Principle?

Cleon. Any Thing that is naturally of a ſpiral, or twiſted Form; particularly the Beard of a wild Oat, and that of ſome other Vegetables; for the Moiſture of the Air inſinuating into the Pores, or between the Parts of thoſe Bodies, expands them, leſſens their natural Elaſticity, and cauſes them to unbend, or gradually to become untwiſted; as on the Contrary, when from a moiſt State in the Air it becomes dry, thoſe Particles by Degrees are exhaled, and the Beard returns again, by Degrees, to its original, twiſted Form; and therefore, if the Beard of a wild Oat be placed in a Perpendicular, and a fine Index placed on the Top of it, over a ſmall Circle, divided into Degrees, it will naturally ſhew the Moiſture, and Drineſs of the Air, by its Motion backward or forward over the ſeveral Parts or Diviſions thereof. And theſe, I think, are the principal Kinds of *Hygrometers*, which have been hitherto invented. I am not, indeed, provided with one of every Sort, to ſhew you; but have a Print of them, which will communicate the Ideas of their Conſtruction and Uſe as perfectly as the Inſtruments themſelves.

Euphroſ. I apprehend the Nature and Deſign of them all very well, from the Prints; but you have not yet told me which Form or Conſtruction you think the beſt of all others.

Cleon. It is difficult to ſay which is the beſt, ſome having an Advantage in one Reſpect, and ſome in another; but that which is moſt convenient for general Uſe, and yet very exact at the ſame Time, is what makes the third Part of the triple Weather-glaſs. This conſiſts of a long, twiſted Cord, which you ſee ſtrained over the Frame of this *Barometer* in a horizontal Poſition.

Euphroſ. I do not clearly ſee how this Cord operates as an *Hygrometer*. I eaſily apprehend, that it muſt be alternately ſlacker or tighter, as the Weather is dry or moiſt; but, how is that Index, which I ſee on the upper Part of the Plate, moved backward and forward over the Semi-circle, by that Means?

Cleon. For this Purpoſe, there is a little Wheel and Axle placed in the back Part of the Frame, which is very freely moveable. About this Wheel, the fine Piece of Silk-ſtring, which you ſee hang from the Middle of the Cord, is put with a ſmall Weight hanging at the End; ſo that, when the Cord relaxes or contracts, the Middle Part will deſcend and aſcend, thro' a ſmall Space; and conſequently, by the String, the Wheel will be moved a little one Way and the other. The End of the Axle of this Wheel comes to the Out-ſide of the Plate, thro' the Center of the Semi-circle; on this the Index is ſcrewed, and, as the Wheel and its Axle move by the String from the Cord, the Index, of Courſe, muſt be carried from one Part of the Semi-circle to the other.

Euphroſ. You have convinced me to my Satisfaction. I eaſily ſee, that when the Cord relaxes, by the Drineſs of the Air, it muſt deſcend a little in the Middle Part, the Silk-ſtring there, by its Weight, will carry the Wheel a ſmall Matter round, and move the Index over the Right-hand Quarter of the Semi-circle, ſhewing the ſeveral Degrees of Drineſs in the Air; but when the Air is moiſt, the String will ſwell, contract, and riſe again in the Middle-part, and carry the Index back to the other Part of the Semi-circle on the Left-hand, and there point out the particular Degree of Moiſture.

Cleon. Your Ideas are very juſt; and I have only one Thing more to obſerve, in regard to this *Hygrometer*, that as it is the moſt ſimple in its Structure, ſo it is the moſt accurate for Uſe, and the leaſt expenſive in the Form.

Euphroſ. I obſerve your main Drift in every Thing is the greateſt Accuracy, joined with the leaſt Expence, in the Structure of Machines for philoſophical Purpoſes; and if one of this Sort will do ſo very well, it muſt certainly render this Weather-glaſs (for indicating at once all the different and important Qualities of the Air) a very uſeful Contrivance. Having detained you, I think, long enough on this Sort of Inſtrument, I ſhall be glad of an Opportunity, when you are next at Leiſure, to have your Inſtructions concerning the Nature and Uſe of that very celebrated Machine, the AIR-PUMP, which I have heard ſo much Talk of, but have never yet ſeen any Experiment made with it.

Cleon. Our next Converſation, my *Euphroſyne*, will be on that Subject; and nothing which the Field of Philoſophy affords can more highly gratify your Curioſity, or improve your Underſtanding, than Experiments made therewith. As we have now ſurveyed the Nature and principal Properties of the vaſt ſurrounding Atmoſphere, and alſo of many different Species of Meteors generated therein, I think, it will be proper for you to conclude this Speculation at preſent, by reading the poetical Deſcription of this Subject, by the Author of the Poem, called, *Univerſal Beauty*, which I ſhall leave with you for that Purpoſe.

While Ocean thus the latent Store bequeaths,
Above, its humid Exhalation breaths;
Its Boſom pants beneath the vig'rous Heat,
And eager Beams th' expanding Surface beat;
Inſinuating, form the lucid Cell,
To Bladders the circumfluous Moiſture *ſwell;*
Th' inflated Vapours *ſpurn the nether Tide,*
*And mounted on the weightier Æ*ther ride;
As tho' in Scorn of gravitating Pow'r,
Sublime, the cloudy Congregations tour;
O'er torrid Climes, collect *their ſable Train,*
And form *Umbrellas for the panting Swain;*
Or figur'd *wanton in romantic Mould,*
Careering Knights, and airy Ramparts hold;
(Imblaz'ning Beams the flitting Champions gild,
And various, paint the viſionary Field;)

Sudden the looſe, inchanted Squadrons fly,
And ſweep *Deluſion from the wond'ring Eye*;
Thence, on the floating Atmoſphere they ſail,
And ſteer precarious *with the varying Gale*;
Or hov'ring, *with ſuſpended Wing* delay,
And in Diſdain the kindred Flood ſurvey.
When lo! th' afflicting Æther checks their Pride,
Compreſſing chill, the vain dilated Tide;
Their ſhiv'ring Eſſence to its Center ſhrinks,
And a cold Nuptial *their Coherence* links,
With artful Touch, the curious Meteor forms;
Parent, prolific *of ſalubrious Storms,*
(When from on high the rapid Tempeſt's hurl'd,
Enliv'ning as a Sneeze to Man's inferior World.)
The frigid Chymiſt *culls the min'ral Store,*
The gloſſy Sphærules of metallic Ore;
Sublimes *with Nitre and ſulphureous Foam,*
And hoards *Contagion in Heav'n's ample Dome*;
Where Nature's Magazine fermenting lies,
Till the bright Ray athwart the Welkin flies,
High Rage the ſmall Incendiary inſpires,
Whoſe kindling Touch the dread Artillery fires;
Quick, with Effuſion wide, the Lightnings glare;
Diſploding Bolts, the cloudy Entrails tear;
The cleanſing Flames ſweep thro' th' etherial Room,
And ſwift, the groſs infectious Steam conſume,
Our vital Element the Blaze refines,
While Man, ingrateful, at his Health repines.
With various Skill, the chilling Artiſt works,
And Operator chief, *in ev'ry Meteor* lurks;
Oft, where the Zenith's lofty Realms extend,
E'er Miſts, conglobing, by their Weight deſcend,
With ſudden Nitre captivates *the Cloud,*
And o'er the Vapour throws *a whitening Shrowd*:
Soft, from the Concave, hov'ring Fleeces fall,
Whoſe flaky Texture cloaths our ſilver Ball.
Or when the Show'r forſakes the ſable Skies;
Hap'ly, the Cold *in ſecret Ambuſh* lies,

Couching, awaits *in ſome inferior Space,*
And chills *the Tempeſt with a quick embrace;*
The chryſtal Pellets at the Touch congeal,
And from the Ground rebounds the murm'ring Hail.
Or conſtant, where this Artificer dwells,
And algid, *from* his *Heights the Miſt* repels;
Th' ALMIGHTY ALCHYMIST *his Limbeck rears,*
His Lordly Taurus, *or his* Alpine Peers;
Suſpending Fogs *around the Summit ſpread,*
And gloomy Columns crown *each haughty Head;*
Obſtructed, drench *the conſtipating Hell,*
And ſoaking, *thro' the porous Grit* diſtil;
Collecting *from a thouſand thouſand Cells*
The ſubterraneous Flood *impatient* ſwells;
Whence iſſuing Torrents burſt *the Mountain's Side,*
And hence impetuous pour *their headlong Tide.*

DIALOGUE XI.

Of the INVENTION *and* CONSTRUCTION *of the* AIR-PUMP.

Euphroſyne.

THE preſent Hour, I ſee, is deſtined for my Information in a Part of Knowledge that I have as yet few or no Ideas of. ——— This Machine, I preſume, is what you call the *Air-Pump*; it appears to be of a curious Form and Make; and I ſhall be highly pleas'd with a ſhort Account of the original, or firſt Invention of it. Can you tell any thing of that Matter, *Cleonicus?*

Cleon. The Inventor of this famous Machine was *Otto Guericke*, a Conſul of *Magdeburg*, who, ſome time before the Year 1654, firſt contrived and brought it into Uſe; for it was then, that this ingenious Gentleman, being employed in a public Negotiation at *Ratiſbon*, had an Occaſion offered him of ſhewing his Inſtrument to the Emperor, and ſome other Princes there preſent; among whom, the Elector, and Archbiſhop of *Mentz* were particularly delighted with the Contrivance of the Inſtrument, and the curious Experiments exhibited by it; inſomuch that he became very deſirous of having ſuch another Machine made for his own Uſe: But this could not eaſily be effected, by Reaſon of the ſhort Stay they had to make at *Ratiſbon*, and for want of ſkilful Workmen. However, he prevailed with the Inventor to part with his own Apparatus; and at his Return, carried it home with him to *Wurtzburg*. Here it was, that the learned and diligent Jeſuit, Father *Schottus*, being then Profeſſor of the Mathematics in that Univerſity, had the firſt Sight of it, together with ſome other curious and learned Perſons. The Archbiſhop was pleaſed to give them an Account of the Engine; and a Relation of the Experiments he had ſeen the Inventor perform at *Ratiſbon*. Theſe they tried over ſeveral Times in his Preſence; and it was not long before they themſelves alſo made ſeveral other new ones of the like Nature.

Euphroſ. I do not wonder at their being highly delighted with ſuch a curious Invention, and which, I ſuppoſe, ſoon made a great Noiſe in the World at that Time, and ſoon reached the Ears of moſt of the *Virtuoſi* in *Europe*.

Cleon. Indeed it did; principally by Means of the large Correſpondence which *Schottus* held with learned Men in moſt Parts of *Europe*; but more eſpecially by a Book, which he publiſhed in the Year 1657, in which, and in an *Appendix* added thereto, he gave a diſtinct and full Account of this Machine, and the *Magdeburgic* Experiments, as he calls them. After this, in the Year 1664, he publiſhed another Book, giving a farther Account of the Experiments that had been made ſince the printing his Former; and laſt of all, in the Year 1672, the famous Inventor himſelf, *Otto Guericke*, was pleaſed to give a moſt perfect Narrative of his own Trials, in a Book, which he calls, *New Magdeburgic Experiments* in *Vacuo*. Theſe Books all explain the original Conſtruction of this Inſtrument, which, it muſt be confeſſed, was very aukward and imperfect, in Compariſon of the Forms in which they are now made; for, in order to try Experiments with them, they were obliged to place their Glaſſes, and other Veſſels (from which they would exhauſt the Air) under Water, in order to prevent the Air from getting in again.

Euphroſ. No Wonder, if there has been a gradual and very conſiderable Improvement in an Engine of ſuch an extraordinary Nature, and I imagine, it was not long before ſome of our *Britiſh* Geniuſſes took it in Hand; for I have often heard it obſerved, that the *Engliſh* never fail to improve upon the Hints they receive of any foreign Invention; and, indeed, I have heard ſo much Talk of *Boyle*'s Air-pump, that I really took it for granted, he was the Inventor of it. I ſuppoſe, therefore, it was he, among our Countrymen, who firſt made any Progreſs in its Improvement.

Cleon. So far you are right, Siſter; and Multitudes think as you do, that Mr. *Boyle* was the Author of this Invention, from its having been ſo generally called the *Machina Boyliana*; and the void Space produced by it, the *Vacuum Boylianum:* But theſe Appellations were rather the Conſequence of his great Improvements in the Fabric of the Machine. His new Method of trying Experiments with it, and the numberleſs uſeful Purpoſes to which he applied them, the Glory of which has, in a Manner, totally obſcured all that had been heard of before in the *Magdeburgic* Experiments. Mr. *Boyle* himſelf gives a true Account of the Invention of this Machine, as I have now mentioned, in a Letter, which he wrote to his Nephew, the Lord *Dungarvon*, at *Paris*. Two Years after *Schottus*'s Book was firſt publiſhed, he does, indeed, ſay, that he had ſome Thoughts on the ſame Subject before he had heard of thoſe Gentlemens Performances Abroad; but that they had really anticipated him in the Invention of the Machine: But he obſerves to his Lordſhip the great Imperfections the Invention then laboured under, and imployed two Gentlemen, Mr. *Gratorix* and Mr. *Hooke*, afterwards Dr. *Hooke*, to contrive ſome *Air-Pump*, which need not, like that other, be kept under Water, and be more eaſily and generally applied to Uſe, which after ſome unſucceſsful Trials was at Length accompliſhed.

Euphroſ. Are the Air-pumps now in Uſe of this original Form of Mr. *Boyle*'s.

Cleon. No; far enough from it: His own Alterations were not a few. Dr. *Hooke*'s Pump ſerved him not long; another Form, invented by Mr. *Pappin*, pleaſed Mr. *Boyle* ſtill better, and ſucceſſive Changes and Improvements were made; till at laſt, it arrived to the Perfection which it received from the Hands of that excellent Operator, the late Mr. *Hawkſby*, which is ſtill one of the Forms in Uſe; and is this large Engine, which you ſee in this upright Frame.

Euphroſ. An elegant and noble looking Machine, indeed! Pray, what may be the Expence of it?

Cleon. This, which you ſee in this Mahogany Frame, with this large Apparatus of Glaſſes, Braſs-work, *&c.* coſt 30 Guineas.

Euphroſ. I do not think it dear. Were I a Man, I ſhould much ſooner part with that Sum of Money for ſuch an Object, than hundreds of others, on which it is often expended. In Truth, I wonder at nothing more, than to ſee how free and ready Gentlemen are in the expenſive Purchaſes of trifling Subjects, and negligent of thoſe of the greateſt Curioſity, and moſt general Importance. ——— But, I obſerve, you have other Forms of Air-pumps; three of which, I ſee, here upon the Table. Pray, what is peculiar to each of them?

Cleon. Two of theſe are alſo double barrell'd Air-pumps, and the other is a ſingle One. The firſt, or largeſt, was made for the Conveniency of placing it upon the Table, while the Operations are performed on it. Theſe were made, at firſt, by one *Davenport*, and called, *Davenport's Table Air-pump.* The Second was contrived to be of a portable Form, and to reduce the Mechaniſm to a ſtill more ſimple Structure. This, therefore, is called, the *portable Air-pump.* The laſt is a ſingle barrell'd *Air-pump*, and is a ſingular Improvement of this Machine for ſuch, as are very curious in *pneumatical* Experiments.

Euphroſ. The external Appearance of theſe Machines muſt highly delight the Eye; but the *Rationale* of their Structure and Uſefulneſs, I preſume, depends upon a particular View of their internal Parts.

Cleon. It is certain, you cannot know the Nature, or Uſe, of an *Air-pump*, without being particularly acquainted with its internal Structure and Parts; and I propoſe, in the next Place, to analize one of them, or take it to Pieces; and you will find, that the conſtituent Parts are not many, and their Uſes not difficult to be underſtood. For this Purpoſe, I ſhall take in Hand the portable *Air-pump*, as that contains no more Parts than are abſolutely neceſſary, in a Form where two Barrels are uſed.

Euphroſ. The Parts of this Pump are ſo few in Appearance, that, I imagine the Diſſection of it will not be either tedious or troubleſome.

Cleon. It will not in the leaſt. ——— For you ſee, I only take theſe Screw-pins out, and the Head, or Top of the Pump, divides itſelf into two Parts, which fall off; ſhewing the Wheel, with the Piſterns, on each Side, which it moves alternately up and down in the Barrels, when itſelf is turned round by the Winch.

Euphroſ. This I plainly perceive, and that the Uſe of the Frame is only to keep theſe Parts together in their proper Poſitions, in working the Inſtrument.

Cleon. I remove the Wheel, and the Barrels eaſily come off, as they were only before preſſed down by the Frame of the Pump, which ſcrews on the Top for that Purpoſe. The Cavity of theſe Barrels is exactly fitted, by the lower Part of the Piſterns, by Means of Leather, ſuppled with Oil, ſcrewed on to each; ſo that no Air can, or ought to paſs between them and the Barrels. The next Thing that you obſerve is, that the Piece, ſcrewed on at the Bottom of each Piſtern, is perforated with a Hole through the Middle, over which Hole, you ſee is tied a ſmall Piece of Leather, which is called the *Valve*; and as this Part is ſcrewed into the Piſtern, this *Valve*, opening upwards, gives a Paſſage for the Air through it from below. —— Again, in the Braſs Plate, on the Bottom, you ſee other Pieces of Braſs ſcrewed in, having Holes, in like Manner, through them, with the ſame Leather *Valves* on the Top, as before, in the Piſterns; ſo that, by this Means, there is a Paſſage for the Air from any Receiver, placed on the circular Plate of the Pump, to the Cavity of the Barrels below, which ſtand over thoſe Parts; for this large Plate of the Pump is perforated with a Hole, quite to the Center of the Fore-part, and thence croſs-wiſe on each Side the Barrel. ——— Theſe Parts, few as they are, are all that are eſſential to Pump-work of any Kind; for there is no Difference in the Nature of the eſſential Parts of a Pump, whether it be for exhauſting Water, Air, or any other Fluid.

Euphroſ. Theſe Parts, I obſerve then, are only two Barrels, two Piſterns, one Valve in each of them, and one Valve under each Barrel, in the Plate of the Pump; beſides the Wheel, which gives Motion to the Piſterns: —— But how am I to underſtand the *Rationale* of working this Machine, when all the Parts are put together in their proper Place and Order?

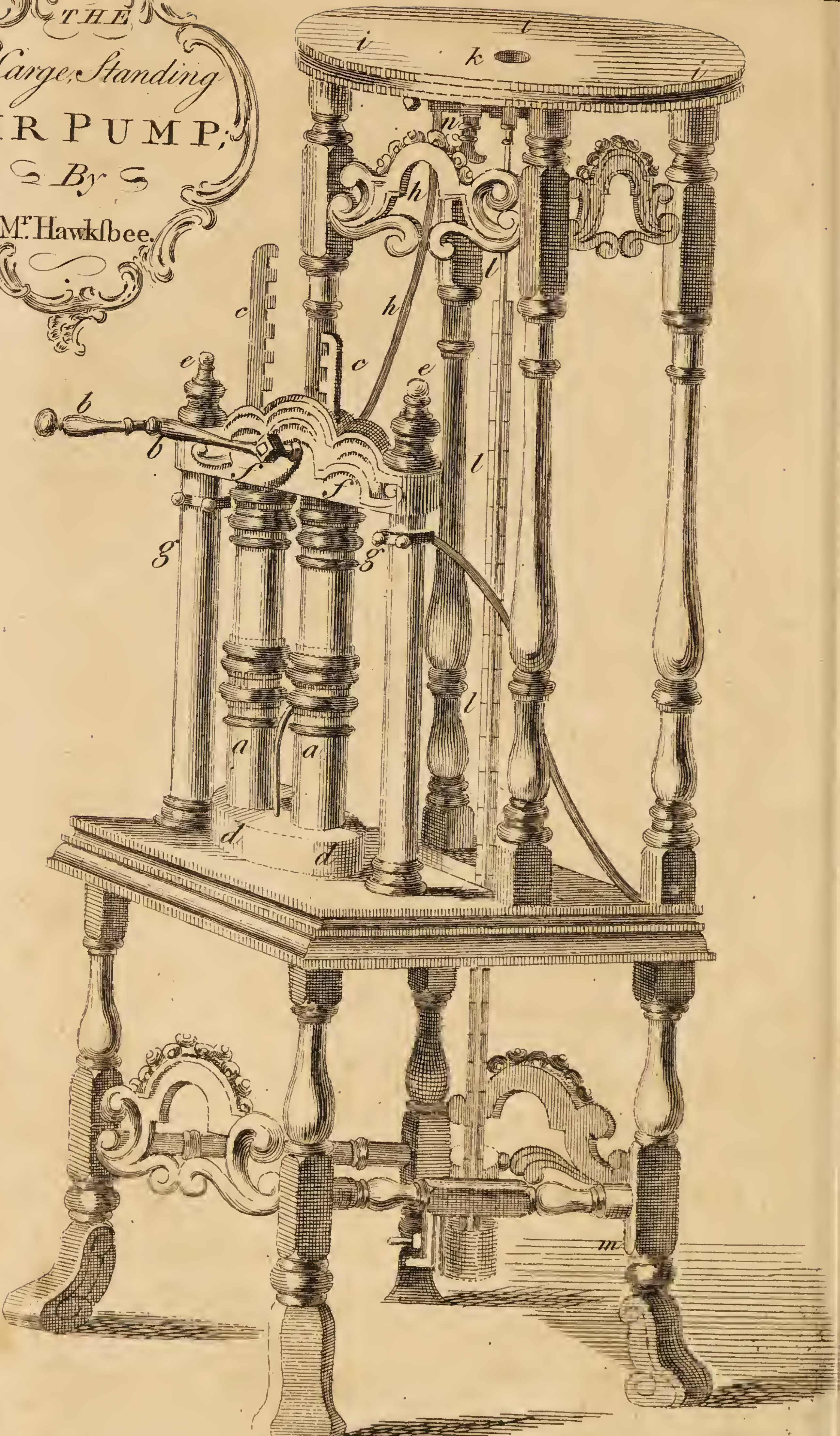
Cleon. You will thus eaſily underſtand it, by conſidering the Thing in a proper Manner; that is, the Action of one Barrel by itſelf alone. ——— In the firſt Place, you ſee the Piſtern is placed at the Bottom of the Barrel; and it is ſuppoſed, that it fits the Barrel ſo very nicely, as to leave little or no Air below it.—— Then (ſecondly) I turn the Winch, and lift up that Piſtern to its proper Height. —— Thirdly, in doing this, I lift up the Column of Air that ſtands over the Piſtern, and thereby make, in the Cavity below, a Space, in a great Meaſure void of Air, ſuppoſing that none could enter into it thro' the Valve in the Plate of the Pump. —— Fourthly, but upon lifting up of the Piſtern, the Air from the Receiver, placed on the Pump, will not ſuffer this void Space in the Barrel; but, by Means of its Spring, will ruſh into the Barrel thro' the Valve at the Bottom, till the Air in the Barrel, and in the Receiver, be of equal Denſity; and conſequently, That in the Receiver is by this Means rarified, or becomes leſs denſe, by being expanded into a larger Space. —— Do you underſtand me thus far, my *Euphroſyne?*

Euphroſ. I believe I do pretty well; but as yet you have performed but one half of the Operation.

Cleon. 'Tis true, we have not; for the Piſtern, in the next Place, muſt be carried down to the Bottom of the Barrel again; by raiſing the Piſtern up, we have brought ſome of the Air out of the Receiver into the Barrel, and now by depreſſing the Piſtern, we ſhall get it out of the Barrel too, and ſo get rid of it quite. ——— Thus I force the Piſtern down to the Bottom, by turning the Winch the contrary Way; in which Action, you'll obſerve, (firſt) That, as the Piſtern goes down, the Air, contained below it in the Barrel, as it cannot return thro' the Valve at the Bottom into the Receiver, muſt be condenſed by Degrees, till at length, it becomes of equal Denſity to the external Air above the Piſtern. (Secondly) After this, as the Piſtern deſcends lower, the Air will become more condenſed in the Barrel than the

Plate X

THE
Large, Standing
AIR PUMP;
By
Mr. Hawkſbee.



the outward Air, if it had no Paſſage through a Valve in the Piſtorn; but, as there is ſuch a Paſſage, it can ſuffer no greater Condenſation; becauſe, by its greater Spring, it will ruſh thro' the Valve in the Piſtorn, and make its Eſcape into the common Air, from whence it cannot return, as we have before ſaid, by reaſon of the Valve in the Piſtern ſhutting downwards, by the Preſſure of the incumbent Air. Thus we have exhauſted a Part of the Air out of the Receiver, and the remaining Air will be gradually very nearly all exhauſted, in the ſame Manner, by the conſtant Working of the Pump; for the Piſtorn in the other Barrel does the ſame Thing, as you have now ſeen; and as they are both worked by the ſame Stroke of the Winch, their Action may be alternately repeated, till the Air is exhauſted from the Receiver, as far as is required.

Euphroſ. My dear *Cleonicus*, you take great Pains to inform me; and, I hope, I am not ſo dull a Scholar, but that I can in general underſtand all that you have ſaid; and I doubt not, when I come to ſee ſeveral Experiments of this Nature performed, I ſhall gradually get a more perfect Knowledge thereof.

Cleon. I make no Doubt but you will; for bare Inſtruction, without an Illuſtration by Experiments, will require, not only great Capacity, but great Attention, to comprehend what will otherwiſe be very eaſily deduced from Facts, joined with a proper Method of reaſoning on them.

Euphroſ. I preſume the Mechaniſm of the Pump, in the ſeveral Parts we have now deſcribed, is the ſame nearly in all the different Forms.

Cleon. It is ſo, in thoſe which you ſee conſiſting of two Barrels; and likewiſe, in the ſingle Barrel Pumps of the common Sort; but that One which you here ſee is of a peculiar Make, the Rationale of which deſerves, in a few Words, to be explained; in order to which, it muſt be obſerved, that, when the Piſtern is raiſed in a ſingle Barrel, as the Weight of the Atmoſphere lies upon it, ſo that Weight lies upon the Hand, in every Stroke of the Piſtorn. Indeed, when we firſt begin to work the Pump, that Weight is inſenſible, by reaſon that the Spring of the Air below the Piſtorn is equal to the ſaid Weight above it; but in every Stroke of the Piſtorn, the Spring

of

of the Air below it, which comes from the Recipient, is diminiſhed, while the Weight of the Atmoſphere in the Piſtorn remains the ſame; and therefore, will be more and more ſenſible, as you proceed in working the Pump; till at laſt, when the Air is nearly all exhauſted from the Receiver, the whole Weight nearly of a Column of Air, upon the Surface of the Piſtorn, muſt be raiſed by the Hand alone, without any Aſſiſtance from the Spring of the internal Air.

Euphroſ. I apprehend what you ſay, and muſt naturally aſk this Queſtion; why then are ſuch Pumps in Uſe? For the Labour muſt needs be very great in working them, as you have heretofore convinced me, that the Weight of the Air, upon a circular Inch, is 12 Pounds, and conſequently, if the Piſtorn of the Pump be any thing conſiderable, ſuch a conſtant Weight of the Air, and the Labour it cauſes, would diſcourage the Uſe of ſuch Pumps.

Cleon. The Query you put is very pertinent; to which it is replied, that if the Piſtorn be made ſmaller, the Weight will be thereby leſſened, in Proportion to the Square of the Surface; ſo that a Piſtorn, half an Inch in Diameter, ſuſtains but a fourth Part of the before-mentioned Weight, or only four Pound; but, as when the Piſtorn is ſmall, the Strokes muſt be many more in Number, this Weight tho' leſſened, muſt be often repeated, which cauſes a Diſlike in People to theſe Pumps after all; eſpecially, if we add to this, that the Expence of a ſingle Barrel Air-pump, with its proper Apparatus, is nearly as great as that of a double barrelled Pump, of the portable Form you here ſee.

Euphroſ. It was on this Account then, I preſume, that we have the Invention of the ſingle barrelled Pump, you here recommend. I ſhould be glad to know what are the particular Advantages of this Conſtruction, and the Principles on which they depend.

Cleon. The principal Deſign in this Pump, is to render the Weight of the Air inſenſible on the Hand in working; for which Purpoſe, you ſee a Valve is provided in a Piece fixed to the upper Part of the Barrel, and a Collar of Leathers, thro' which the Shank of the Piſtorn paſſes in a Piece, ſcrewed on upon the Top of the Barrel. The Effect of this Valve is twofold;

for, firſt, it gives a Paſſage for the Air out of the Barrel; and ſecondly, prevents any Preſſure of the outward Air upon the Piſtorn in the Pump, excepting what lies upon the ſmall Hole in the Valve, which is altogether inconſiderable and imperceptible; and farther, as the Air cannot return by this Valve, ſo neither can it get thro' the Braſs Piece in which the Piſtern moves, by reaſon of the Leathers ſitting very cloſe about it, and well ſuppled with Oil, which, at the ſame Time, by no means prevents a free and eaſy Motion of the Piſtorn: This Contrivance of a Collar of Leathers, you will obſerve in the Courſe of our Experiments, will be of neceſſary and frequent Uſe in many other Caſes of a like Nature. Beſides theſe Particulars, there are ſome other Improvements which the Author of this Contrivance has made in the Structure and Apparatus of an Air-pump; ſo that thoſe who chuſe it may exhauſt the Air from any Veſſel, as far as the Power of Mechaniſm, and the Nature of Air will permit.

Euphroſ. But how do you find in what Proportion the Air is exhauſted from any Veſſel placed on the Pump?

Cleon. By means of a Gage, which is provided for that Purpoſe, of different Forms, according to the different Kinds of Pumps that are uſed. This Gage conſiſts of a Glaſs Tube, immerſed in a Baſon of Quick-ſilver, in the large * Air-pump. This

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* The moſt elegant Form of this Pump we have thought proper to give a Print of, for the Sake of explaining the ſeveral Parts of which it conſiſts, which are the following:

a a, The two Braſs Barrels of the Pump.
b b, The Handle, or Winch, by which
c c, The two Piſtorns are worked in the Barrels.
d d, A Braſs Eliptic Baſon, which was formerly in Uſe for holding Water to ſupple two Leathers in the lower Part of the Baſon, but is now diſuſed, as not neceſſary.
e e, Two ornamental Pieces of Wood, by which
f f, The Head of the Pump is ſcrewed very faſt down upon the Barrels.
g g, The two Pillars ſupporting the ſame.
h h, A long Pipe, by which the Air paſſes from the Receiver into the Barrels.
i i, The Braſs Plate, on which the Receivers are placed, to be exhauſted of their Air.
k, The Hole in the Middle of the ſaid Plate.
l l, The Mercurial Gage.

m, The

This Tube communicates, on the other End (by means of a Piece of Braſs) with the Hole in the Plate on the Top of the Pump; and conſequently, with the Receiver, placed over it; ſo that, when the Air is drawn from the Receiver, it is, at the ſame time, taken from the Glaſs Tube, or Gage; and as the Spring of the Air, within the Gage, is by that means leſſened, the Preſſure of the outward Air becomes greater, and forces the Quick-ſilver up in the Tube; ſo that, as the Quantity and Spring of the Air is leſſened in the Receiver, the Quick-ſilver riſes higher and higher in the Tube, and could the Air be entirely exhauſted, the Mercury would be juſt as high in the Gage, as it ſtands at that Time in a common Barometer; and to convince you of this, ſhall be the firſt Experiment on the Pump.

Euphroſ. This will give me great Pleaſure. Pray proceed to the Operation.———I ſuppoſe the Diviſions on the long Slip of Wood are ſo many Inches, by which you meaſure the Riſe of the Quick-ſilver.

Cleon. That is the Uſe of it.———To prevent the Air from getting into the Receiver, I firſt place this wetted Leather on the Plate of the Pump, with the Hole in the Middle of it, juſt upon the Hole of the Plate. Then I take the ſmall Receiver, and place on the Leather over the Hole.——I turn the Winch, and raiſe the Piſtorn from the Bottom of the Barrel towards the Top, and you ſee the Quick-ſilver immediately riſe in the Gage.———I turn the Winch back, and the other Piſtorn riſing, draws out more Air, and makes the Mercury riſe ſtill higher.———I proceed in the Operation, and each alternate Stroke of the Piſtorn advances the Quick-ſilver ſtill higher and higher; till at laſt,———I move the Piſtorns many Times up and down, without the Mercury ſenſibly riſing any higher. ———Whence you may conclude, that the Air is drawn out of the Receiver and Glaſs Tube, as far as the Pump can do it.

m, The Baſon of Mercury, in which it is immerſed.

n, The Stop-Cock, by which the Air is let into the Receivers again.

Theſe are all the eſſential Parts of the Pump neceſſary to be deſcribed; the Apparatus proper for Gentlemens Uſe we ſhall exhibit in a Plate hereafter.

Euphroſ. I obſerve the Motion of the Quick-ſilver riſing with every Stroke of the Piſtorn, with the higheſt Satisfaction; and by this one Experiment only, can ſee a great Way into the Nature and Uſe of this curious Engine. But what is the Form and Rationale of the other Gage you mentioned?

Cleon. I will tell you, and ſhew its Uſe by an Experiment alſo.———It conſiſts of a ſhort Tube, hermetically ſealed at one End, filled with Quick-ſilver, and inverted with the open End into a ſmall Baſon of Quick-ſilver, and then placed on a ſmall Plate, communicating with the common Duct of the Pump, as you here ſee it on the portable Air-pump.

Euphroſ. I ſee it indeed, but I do not rightly underſtand it. ———It ſeems to me, as if this Gage was to ſhew how far the Air was exhauſted by the Motion of the Quick-ſilver downward.

Cleon. You judge very rightly; for, as the Air is drawn out of the Receiver, it is, at the ſame Time drawn out of the Glaſs, placed over the Gage; and conſequently, the Spring of the Air on the Quick-ſilver in the Baſon being conſtantly diminiſhed, it will at length become leſs than the Weight of the Mercury in the Tube, at which Time the Mercury will begin to ſubſide; and as the Operation of the Pump is continued, it will ſink lower and lower, till at laſt, it will ſtand but a very ſmall Heighth above the Surface of that in the Baſon: Whence, likewiſe, we ſhall know, that the Air is drawn out as far as it can be.

Euphroſ. I perfectly underſtand you.———But one Thing I muſt obſerve, that you ſeveral Times hinted, that the Air cannot be wholly exhauſted from the Receiver.———Pray, give me the Reaſon for that.

Cleon. You will eaſily perceive the Reaſon of it, when you conſider, that, tho' the Quantity of Air be diminiſhed by each Stroke of the Piſtorn, and its Spring thereby continually leſſened; yet, if the Operation of the Pump were to be continued ever ſo long, the Conſequence could only be a continual Dimunition of the Quantity of Air; but a Total Exhauſtion of it will be impoſſible, becauſe the Piſtorn can take away no more Air than what is forced into the Barrels by the Spring of the remaining Air in the Receiver. Therefore, after the laſt

Stroke of the Piſtorn, there will be ſome Air remaining, but that may be ſo ſmall, as not to be capable of throwing up the Valve any longer, and therefore muſt remain exhauſtible: But theſe Valves and Gages have been ſo ingeniouſly contrived and improved, that the Quantity of Air may be exhauſted to much leſs than the thouſandth Part of the Whole; and there are not wanting a few among the Wealthy, who have been liberal enough to encourage this Species of Ingenuity to the utmoſt Extent of Art.

Euphroſ. Were I among the fortunate Number, where Affluence exceeded the neceſſary Occaſions of Life, ſo far as to put it in my Power to have what I can wiſh, I would not only have an Air-pump, but every other philoſophical Inſtrument that the Improvements of the preſent Age could ſupply.

Cleon. This would be making a proper Uſe of the Gifts of Fortune, and doing Good with the beſt Grace and Taſte; it would be happy for Artiſts and Tradeſmen, if more of the Opulent were found of that Diſpoſition.——But Others muſt be provided for, and Pumps of the common Form and eaſy Price will anſwer all our Purpoſes very well; as you will perceive by a Series of Experiments on the portable Air-pump, which I ſhall next proceed to exhibit.

Euphroſ. I long till you make a Beginning; as from what I have already ſeen, I promiſe myſelf not a little Pleaſure and Improvement by them. You have already ſhewn me one Experiment, and I want to ſee what will be the Subject of the Second.

Cleon. For the ſecond Experiment, I take this ſmall Glaſs, and place over the Hole of the Pump, as before, and when I have worked the Pump,——you perceive the Weight of the Air in a viſible Preſſure of the Glaſs into the wet Leather.——I ſoon exhauſt the Air: The Quick-ſilver you ſee at 29 and $\frac{1}{4}$,——and now, if you try to pull the Glaſs up, you will be ſtill further convinced of the Weight of Air in preſſing it down;——Try what you can do.

Euphroſ. I will——but it ſticks ſo faſt that I cannot.——Sure! It can never be the Weight of the Air that keeps it thus faſt upon the Pump.

Cleon. It certainly is, and nothing elſe; you muſt conſider, the Surface of this Glaſs is about four ſquare Inches, and therefore ſuſtains a Preſſure from the Atmoſphere of fifty Pounds Weight. No Wonder then, if your tender Arm ſhould not be able to raiſe it from the Plate.

Euphroſ. Have you any Experiment by which you can prove this to be owing entirely to the Weight of the Air?

Cleon. Yes; that will be a third Experiment, and give you an ocular Demonſtration of the Truth. ——— I take the ſame Glaſs, and place it under a large Receiver, and on one Side of the Hole on the Plate. ——— Then, when I begin to pump, if you look at the Rim of the ſmall Glaſs, you will obſerve it will be a little lifted up from the Leather, by the Spring of the Air throwing itſelf out from under it into the large Receiver; eſpecially, at a few of the firſt Turns of the Winch.—— The Air is now exhauſted far enough. ——— The ſmall Glaſs has now but little Air within it, and is eaſily moved, as you ſee by my ſhaking the Pump. ——— But now keep your Eyes fixed on the Rim, or Bottom of the ſmall Glaſs, and when I turn the Vent-piece to let in the Air, you will perceive the Weight of it will fix the Glaſs upon the Pump, and you will ſee it ſink down into the Leather. ———

Euphroſ. I hear the Air ruſh in, and ſee it fix the Glaſs down in the Manner you mention by its Preſſure. —— A curious Experiment this! and a full Proof of all I deſire to know; for now you have taken the larger Glaſs away, I find it as faſt on the Pump, and juſt as immoveable by my Strength as before. —— Theſe Experiments make the Weight of the Air ſenſible to a ſurpriſing Degree.

Cleon. And you will have more Reaſon to think ſo from the next Experiment, in which you will be a Party concerned; for you are now to lay your Hand on this open Glaſs, placed over the Hole of the Pump. ——

Euphroſ. Not I, truly; I am too well convinced of the Force of its Preſſure, without any farther Experience of the Matter.

Cleon. You need not be afraid, my *Euphroſyne*; you may be aſſured, the Experiment is innocent; and I will put my own Hand on the Glaſs firſt for your greater Satisfaction. —— You obſerve, I lay on the fleſhy Part of my Hand, and work the Pump with the Other. ——You ſee the Fleſh on the Back of my Hand ſenſibly preſſed down between the Bones, by the Weight of the Air : —— And below, within the Glaſs, you as plainly perceive how the Fleſh of my Hand is protruded, or forced down into the Glaſs, by the Spring of the Air contained in it.

Euphroſ. Yes, I ſee all that you mention, and wonder how you could aſk me to try ſuch an Experiment, which gives me ſo much Pain to ſee it performed by Another. ——I ſhould fear leſt it ſhould maim my Hand, by bending it into the Glaſs. Pray, take your Hand off, *Cleonicus*; for it has a very diſagreeable Appearance. —— The Blood is ready to ſtart thro' your Fleſh into the Glaſs.

Cleon. This laſt Circumſtance, which you mention, ſhews the Reaſon why Surgeons take this Method in Cupping, or Scarification; for they take a ſmall Glaſs, fix it over the Part from whence they intend to take the Blood, and with a ſmall Syringe, ſcrewed on the Top of it, they draw out the Air from the Glaſs. The Air contained in the Fleſh below puffs it up into the Glaſs, and the Blood flows in great Plenty towards that Part; and conſequently, thro' the ſeveral little Orifices made before by the Scarificator.

Euphroſ. It is to anſwer the ſame End, I ſuppoſe, that I have ſeen ſome hold the Cupping-Glaſs over the Flame of a Lamp, and then immediately apply it to the ſcarified Part.

Cleon. It is ſo; and one would ſcarcely think what a Quantity of Air the Flame will inſtantly expel from the Glaſs, and thereby fit it for the Purpoſe. —— But to return from this Digreſſion; you muſt not think to come off without laying your Hand on the Glaſs; and becauſe you ſhall not be afraid, I have provided one of a leſs Size.——I will alſo ceaſe working the Pump, whenever you deſire me to do it.

Euphroſ. I am very timid, and yet have ſome Inclination to try the Experiment, as I love to be convinced of the Truth of Things by all the Means of Senſation.——But be ſure work the Pump very gently.

Cleon. That you may depend on; therefore put on your Hand ſo cloſe that no Air can get under it into the Glaſs.——

I give one Turn of the Winch, and you find a ſenſible Preſſure on your Hand, and ſwelling of the Fleſh within the Glaſs. ——A ſecond Stroke renders this ſtill more ſenſible; —— by the Third——

Euphroſ. —— Oh! *Cleonicus*, remember your Promiſe, and ſtop the Pump; for my Hand is ſo ſucked in, that I am not able to bear it any farther. It is fixed ſo faſt down, that I cannot remove it.——

Cleon. You cry out before you are hurt.——I muſt give you one more Turn of the Winch. —— I don't mind your Panic, it cannot hurt you; therefore you muſt have another Stroke yet.——

Euphroſ. I beg you will proceed no farther. If you do, I ſhall not think you regard me with the Tenderneſs of a Brother. ——How ſhall I do to get my Hand off? —— Pray, diſengage me immediately.

Cleon. I ſhall inſtantly releaſe you from this philoſophical Thraldom which you ſeem to be in.——You have not Half the Courage of ſome of your Sex, whom I have ſeen ſuſtain the whole Weight of the Air upon their Hand on a wider Glaſs than this, without any Out-cry at all: —— But I turn the Stop-cock, and you find no more of the Weight of the Air without, nor the Spring within your Hand.

Euphroſ. I am glad I am once more at Liberty, and muſt confeſs, I am not ſo much of a Heroine as not to be fearful in ſuch Caſes, where I know Danger may attend an Enterprize, and at the ſame Time know not when, or how it may begin. —— I make no Doubt, but you find Gentlemen as timorous as the Ladies in this Reſpect.

Cleon. I will not ſay they are more ſo in general; only this I will aſſure you, I have found many a one whom I could not prevail upon to lay his Hand upon the Glaſs, by all the Importunity I could uſe.

Euphroſ. Well! It makes my Hand affected with an odd Senſation. —— How red the Part appears, with the Circle of the Glaſs impreſt! But enough of this. —— Pray, what is your next Experiment? I hope you have nothing farther for me to do.

Cleon. By the next Experiment, you will further perceive the wonderful Weight of the Air, as it will burſt this Bladder, which you ſee tied over the large, open Glaſs.

Euphroſ. I ſuppoſe you mean, that, when the Air is taken away from the Inſide, the Weight of the Air without is ſo great on the Bladder, as to break its Way through it into the Glaſs.

Cleon. That, you will ſee, will be the Caſe.——— I place the Glaſs on the Pump, and with one Turn of the Winch only, you ſee how the Bladder bends down. ——— With a ſecond Turn, it deſcends ſtill lower.——

Euphroſ. Well! This is a very curious Appearance! The Bladder ſeems perfectly hollow, like the concave Surface of a hollow Globe.——

Cleon. You happen to hit off the Matter exactly; for there is a phyſical Demonſtration, that the Concavity of that Bladder, reſulting from the Preſſure of the Air, muſt be truly ſpherical. ——— But now expect the Conſequence of a greater Preſſure, which will more immediately affect your Ears than your Eyes. ——— I give another Turn or two, —— and the Bladder burſts with the Report of a Gun.

Euphroſ. I imagined I ſhould hear it; but little thought of a Sound ſo great. I aſſure you, I ſhould have ſtopped my Ears, if I had; for it has almoſt made me deaf. ——— Pray, what Weight do you think there might be on the Bladder?

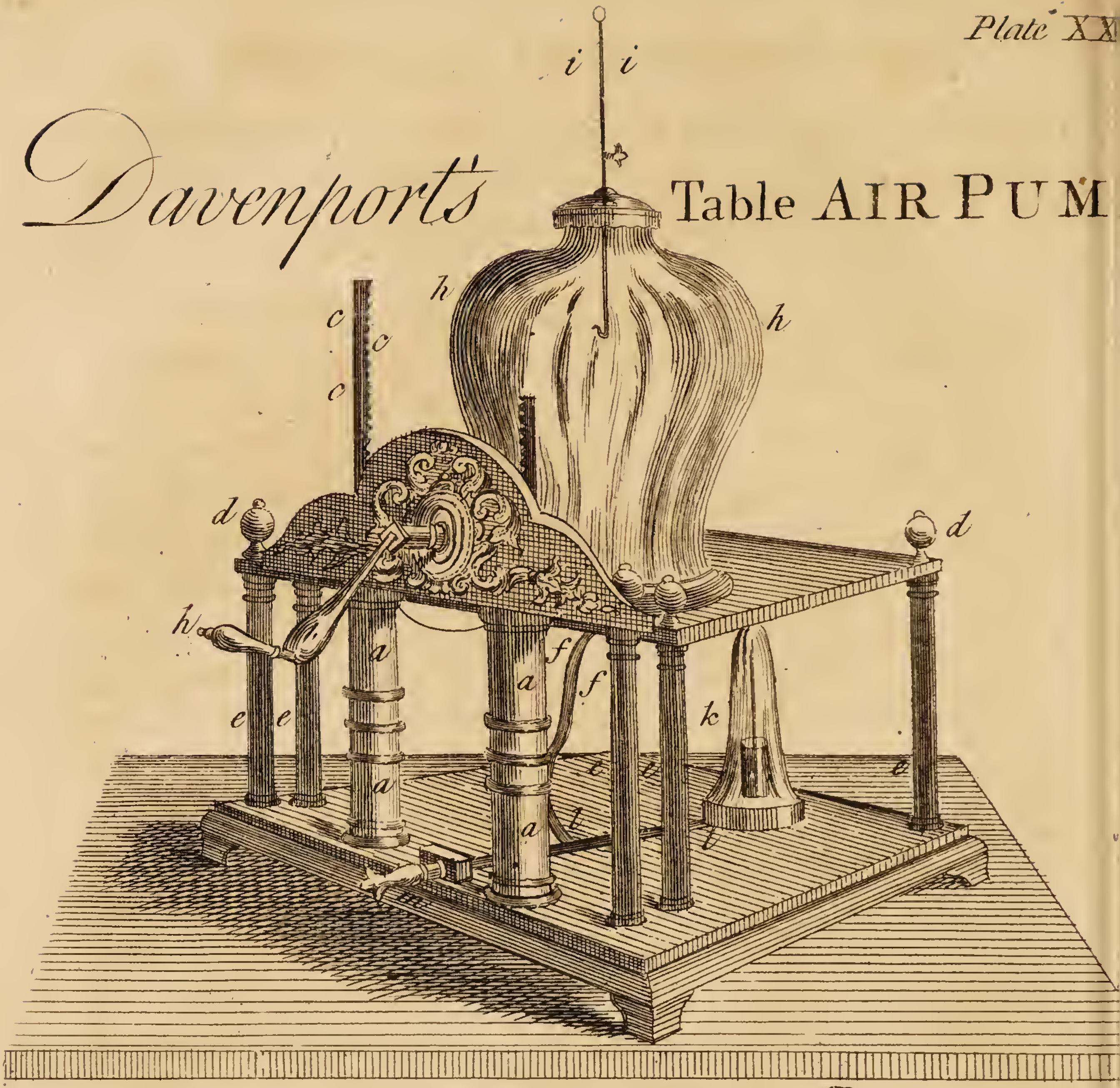
Cleon. The Glaſs is four Inches in Diameter; there is therefore four times four, or ſixteen times the Weight of the Air on the Bladder, as there is in one circular Inch, which, as I have obſerved to you before, is 12 Pounds; ſo that the Whole is 12 times 16, or 192 Pounds. No Wonder, therefore, if the Bladder breaks with the Preſſure of near 200 Weight.

Euphroſ. Such Experiments as theſe naturally tend, by Degrees, to abate the Wonder we uſually expreſs at ſome mighty Effects we obſerve produced by thoſe inviſible Agents, the Weight and Spring of the Air.

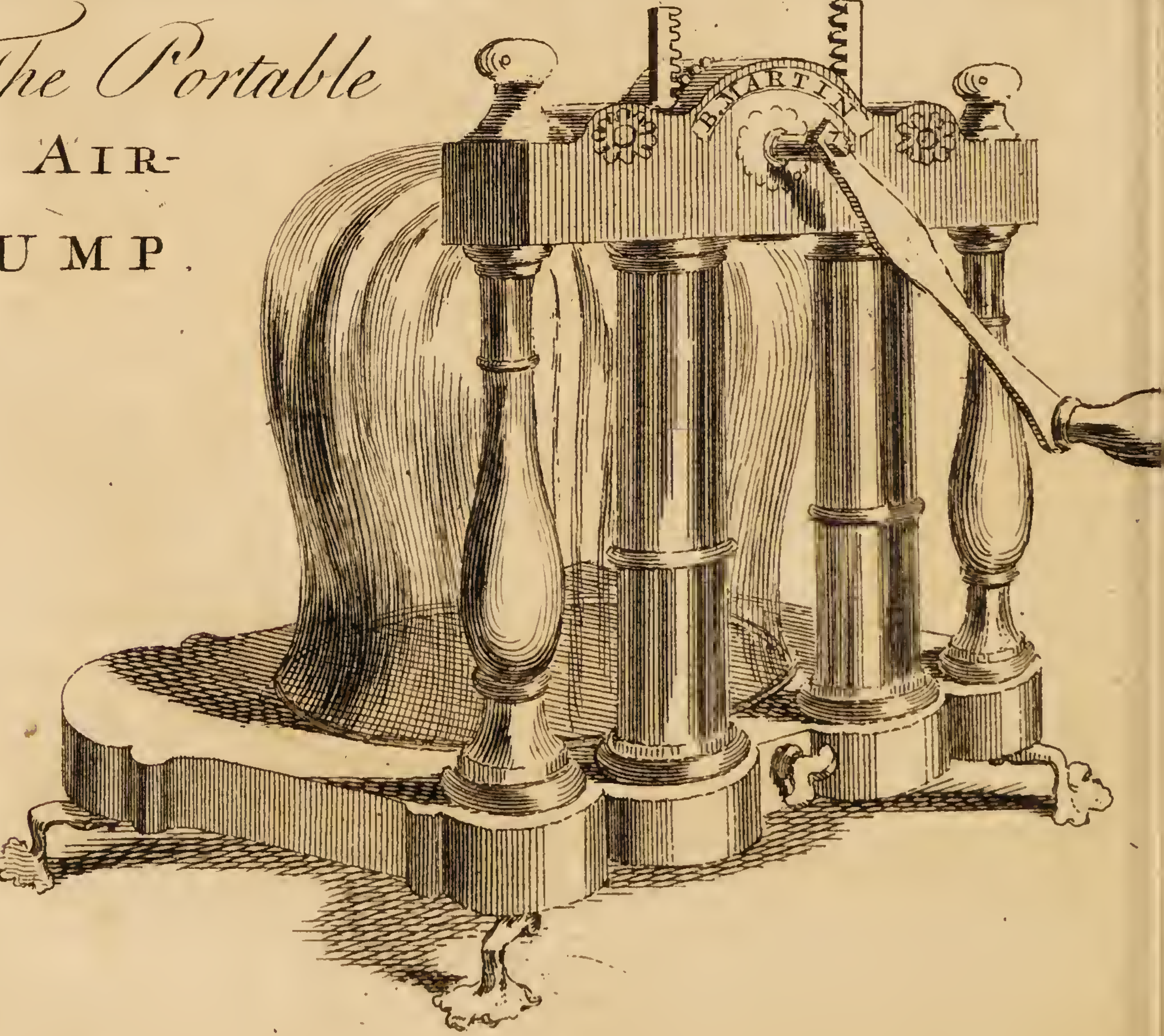
Cleon. They do ſo, to ſee a huge Fire-Engine, worked by one, and the largeſt Bomb-ſhell burſt by the other, create Wonder and Amazement in vulgar Minds; but, when viewed with a philoſophical Eye, they appear to be no other than the

Plate XX

Davenport's Table AIR PUM



The Portable
AIR-
-PUMP.



ordinary Effects of natural Cauſes. ——— The following Experiment will ſhew you how naturally the Air will throw itſelf out, by its Spring, from any Veſſel in which it is contained, when the Preſſure of the external Air is taken away; for which Purpoſe, you ſee here, a ſmall, hollow Globe of Glaſs, with a long Neck to it. —— This Globe, I place on another Glaſs, partly filled with Water, and the Neck immers'd therein nearly to the Bottom. This I place on the Pump, and a cloſe Receiver over it.———Now I turn the Winch, and you ſee how prettily the Air throws itſelf out from the Globe, through the Water, in a Succeſſion of numberleſs Bubbles, and that at every Turn of the Winch.

Euphroſ. See it! Yes, that I do, and with the utmoſt Pleaſure.———I likewiſe obſerve the Reaſon of your placing it under Water; for elſe I could not have ſeen the Air make its Eſcape from the Globe. ——— But I farther obſerve, that the longer your Pump, the leſs is the Quantity of Air thrown out of the Globe at each Exhauſtion; but the Reaſon of this, I recollect, you explained to me heretofore; conſequently, cannot expect to ſee the Air entirely exhauſted from the Globe.

Cleon. I have nearly exhauſted the Air,———and when I turn the Stop-cock to let the Air into the large Receiver, it will neceſſarily fall on the Surface of the Water, and by its Preſſure drive it up into the exhauſted Globe.———You ſee the Effect inſtantly produced.

Euphroſ. It ruſhes with great Violence into the Globe, indeed, and almoſt fills it. ——— The Bubble of Air, which I ſee on the Top, is, I preſume, that which remained in the Bulb, after Exhauſtion, and is now condenſed into a ſmall Space.

Cleon. That is really the Caſe; and you ſee by that, how ſmall the Quantity of remaining Air, compared with the Whole, at firſt contained in the Globe, or to the Bulk of Water now in it, which muſt be equal to the Quantity of Air drawn out; and in common Pumps, it is about the 100th Part of the Whole.———And we ſee, in this Experiment, that the Spring of the Air, in any Quantity, is equal to the Weight of it, by producing an equal Effect; for while the Spring of the internal Air was leſs than the Weight of the external Air, the Water kept riſing in the Globe; but, when the Spring at laſt became equal to the Preſſure, the Water ſubject to both their Influence, and finding it equal on either Side, could no longer move.

Euphroſ. This is a plain Demonſtration of a very important Propoſition, as I take it.———But how do you get the Water out of the Globe again?

Cleon. By a Proceſs juſt the Reverſe of the former Experiment.———Now I take this ſmall Glaſs-jar, and placing it on the Plate of the Pump, I invert the Bottle of Water upon it, and covering the Hole with the Receiver, I begin to exhauſt, ——— and you obſerve, that no ſooner the Winch moves, but the Water begins to deſcend thro' the Neck of the Bottle. ——— It drops only at firſt; but, as the Motion of the Pump is continued, the Motion of the Fluid is accelerated, and at Length it runs in a continual Stream.———This Stream likewiſe is accelerated, till, at laſt, you ſee it all run out, and with the ſame Number of Turns of the Winch as before were made to fill it.

Euphroſ. This is a very entertaining, as well as inſtructive Experiment; for by this, I ſee, that the Weight of Water ſuſtained is always proportioned to the Spring of the Air. As the Latter is leſſened, the Former muſt be ſo of Courſe, till the Spring of the Air within becomes equal to that without. When the Weight of the Water becomes nothing, and conſequently muſt be all run out.———Thus far I have been able to underſtand the Nature of this Experiment. Pray, what Uſe do you make of it, *Cleonicus?*

Cleon. To ſhew the Reaſon of another ſimilar Experiment with an Egg, which I have here provided for that Purpoſe; for, if I make a Hole in the little End of this Egg, and place it with that End downward, as I did the Jar, with the Bubble of Water before, ——— You obſerve, that as ſoon as I turn the Winch, the White of the Egg, and the Yolk are both protruded thro' that Hole, and the Egg becomes entirely empty.

Euphroſ. Indeed, I do obſerve it with very great Pleaſure, and one would think, there muſt be a Bubble of Air in the great End of the Egg, like what we had before in the Bottle, to contribute, by its Spring, to the Expulſion of the Contents of the Egg.

Cleon. You have juſt hit upon the Thing. There really is ſuch a Bubble of Air in the great End of every Egg, and as it is contained between the Shell and the Skin of the Egg, we ſhall have an Opportunity of ſhewing it, by an Experiment in a very curious Manner. Thus ——— I take away with a Penknife near Half the Shell of the Egg, and then placing the other Half upright, on the great End, that you may ſee all the internal Part, I place a ſmall Glaſs over it, ——— and turning the Winch, you ſee the Skin begin to riſe from the Bottom. ——— As I continue to work the Pump, you ſee the Effect of that Bubble of Air manifeſtly, by raiſing the Skin ſtill higher and higher in the Egg. ——— You now ſee the Skin up to the Top of the Egg.———You ſee it riſes ſtill higher and higher, and puts on the Form of that Part of the Egg which is taken away; ſo that now the Skin of the Egg on one Part, and the Shell on the other, make the Egg appear, as it were, again compleat.

Euphroſ. A wonderful Spectacle this, and what I ſhould never have thought of, if I had not ſeen it! ———Indeed, I have often obſerved, in boiling of Eggs, that there was always a hollow Part in the great End between the coagulated White and the Shell; and further, I have often wondered, that the Shell ſhould ſo readily come off at the great End of ſuch an Egg, but ſhould adhere to, and be with Difficulty ſeparated from the White at the little End.

Cleon. You have heard of the old Adage, ——— *There is Reaſon in roaſting of Eggs.*———That very Reaſon, which you now ſee in boiling them, is all contained in this Bubble of Air; and this only one Inſtance, out of many, of culinary Philoſophy; or that which concerns Cookery, which, therefore, ſhews it to be an Art, which is not only neceſſary in Life, but ornamental in your Sex; as it is in every Part founded on the niceſt Principles of natural Reaſoning, and therefore worthy the Study, if not the Practice of every young Lady; and I have the Pleaſure to know, that, for your Part, you excel in both.

Euphroſ. You ſay a great deal, *Cleonicus*; I know your Partiality to me. ——— I know but little, at preſent, of the

Philoſophy of any thing; but I muſt own, that which concerns my own Buſineſs more immediately delights me; and in this, I am but like other People; for every one is delighted to ſee the Reaſon of what he likes.———

Cleon. Nor have we yet taken Notice of the principal Thing diſcovered by this Experiment. ——— For hence we learn, that this Bubble of Air is the Means which Nature has appointed for the Maturation, and bringing to Perfection the Chicken contained *in Embryo*, in what we uſually call the *Treadle* of the Egg. This is done by the conſtant Incubation, or Setting of the Hen upon the Eggs. For by the Warmth, thus communicated to the Air, the Spring of it is increaſed ſomewhat beyond its natural Tenour; and, at the ſame Time, its Parts are put into Motion by this gentle Rarifaction. Hence Preſſure and Motion are communicated to the Parts of the Egg, which, ſome how or other, does gradually promote the Formation, and Growth of the Chicken, in the appointed Time of its Excluſion, or Hatching. ——— This alſo is an Article of natural Knowledge, which will not ſit ill upon the Underſtanding of the good Houſe-wife, who delights in the Breeding of Fowl.

Euphroſ. Indeed, I think ſo too; and every Time I ſee a Hen ſitting, I ſhall be apt to recollect this Part of the preſent Lecture on Philoſophy. ——— It will be hardly worth while, after the mention of Things of ſuch Moment, to ſpeak of that common Experiment, of putting one's Tongue to the great End of the Egg, to find if it be warm; the Reaſon of which, I ſuppoſe, is alſo contained in this included Air.

Cleon. It is ſo; nor is this Experiment to be paſſed over without Notice, as it is the Criterion by which we judge of the Goodneſs of the Egg; for, when the great End of the Egg feels cold to the Tongue, it is a certain Proof of the Egg's being bad; for the Air having made its Eſcape by Degrees thro' the Pores, or otherwiſe, the Egg becomes ſtale, and at Length, grows putrid, or addled. ——— We have long dwelt on the Subject of Eggs, and have not yet done with it neither; but before we can proceed any farther, ſome other Experiments muſt be premiſed.

Euphroſ. Pray, what is the next Experiment, *Cleonicus?*

Cleon. Experiments which next are to ſhew, that Air is plentifully contained in all Kind of Bodies, both fluid and ſolid, tho' we ſee it not, and therefore think little of the Matter. —— For the firſt Experiment of this Sort, I ſhall put clear, cold Water into this tall, Glaſs-jar, and placing another over it, I turn the Winch,——and you ſee the Appearance of Bubbles of Air thro' the Body of the Water.——They appear very thick, but ſmall.——They now grow larger, and riſe to the Top of the Water.——They are now very large, but leſs in Number.——And as long as the Pump continues to work, ſo long you ſee the Air ariſe from the Bottom of the Water to the Top, but more ſlowly, and by Bubbles of a larger Bulk.

Euphroſ. Well! this Pump is a moſt wonderful Machine! Every Experiment adds an Increaſe of Knowledge. —— I could not have thought there had been ſo much Air in Water, had I not ſeen it thus demonſtrated; and thus, I ſuppoſe, Air may be contained in other Fluids as well as Water.

Cleon. In the very ſame Manner, differing only in Quantity; ſome containing more, others leſs. However, one Circumſtance muſt be attended to in ſpirituous Liquors, where ſomething more than mere Exhauſtion by the Pump contributes to the Rarifaction of the Air contained in ſuch Fluids; as you may obſerve, by the following Experiment, —— I take the Jar of Spirit of Wine, cover it, and exhauſt as before.—— And now you ſee how ſuddenly the Air-bubbles ſhew themſelves;——how violently they ruſh to the Top, and burſt: Nay, you obſerve a perfect Ebullition in the Spirit, by the exceſſive Rarifaction and Expanſion of the Air.

Euphroſ. The Spirit perfectly boils, like Water on the Fire, and now I begin to ſee a little into the Nature of Boiling.——

Cleon. You will ſee more, by the following Experiment, of the Nature of this great Operation of the Kitchen; for you will find, that the Pot might be made to boil with an Air-pump, as well as by Fire; but it will be but for a little Time only. —— For now I fill the ſame Jar with hot Water, put it under the Receiver, and exhauſt;—— and you ſee numberleſs Bubbles immediately appear.——I turn the Winch a ſecond Time, and they become large, and ruſh towards the Top.——

A third Stroke produces a great Ebullition, or Boiling of the Water, which now, you ſee, plainly proceeds from the Rarifaction of the Air, occaſioned by the Pump, and the Heat of the Water together. And it is very obſervable, that, at laſt, you ſee the Air is but ſmall in Quantity, and expands itſelf in very large Bubbles. The Boiling of the Water decreaſes by Degrees, and at Length becomes little or nothing, when the Air is nearly exhauſted.

Euphroſ. Theſe Experiments are ſo many Leſſons of Inſtruction. I plainly perceive, that the Boiling of Water is nothing but the Agitation, or Motion produced by the Expanſion of Air, and that this is occaſioned by the Heat of the Fire, when ſufficiently great, as in common Caſes of boiling our Food, or by the Heat of Fire, and the Action of the Pump conjointly, as in this artificial Boiling, you have now ſhewn, and by ſome other Agent, I know not what, in the Boiling your ſpirituous Fluid.———Have you any other Experiment of this Kind for the Improvement of domeſtic Knowledge? ——

Cleon. Yes, many; one in particular reſpects the Air in Beer, which I know will pleaſe you, and therefore ſhall next ſhew it.———Beer, juſt tapped, or new, is fitteſt for this Purpoſe; ſuch as you have in this Decanter. ——— I fill the Jar Half full, and put it under the Recipient. ——— I no ſooner move the Winch, but you ſee the Beer replete with Bubbles of Air. ——— Another Turn makes it almoſt opake, and in Motion throughout;—— a Third makes them riſe to the Top in prodigious Quantities, and theſe conſtitute a frothy, white Head. —— This becomes larger and larger, by the conſtant Riſing of the Air, —— till, at laſt, it runs over the Top of the Glaſs.—

Euphroſ. Well! this is a merry Sort of an Experiment. It makes me ſmile, to ſee ſo odd an Effect. —— I ſee the Beer grow finer, as the Air is exhauſted from it. —— I now likewiſe underſtand why that Beer is always briſk and pleaſant that produces a frothy Head. —— And laſtly, I ſee the Reaſon of the frothy Phenomenon itſelf, *viz.* that by Reaſon of the Viſcidity of the Beer, the Bubbles of Air cannot ſo ſuddenly expand themſelves as on the Top of Water; but lie one upon another in that expanded State, and make that white, and porous Body.

Cleon. You have given the true Reaſon of the Thing; and you will farther obſerve in this Experiment the general Reaſon of Tranſparency, and Opacity in Bodies; for the Beer is more tranſparent, as it contains leſs Air, and the Froth becomes opake, on account of the larger Interſtices, or Bubbles of Air; therefore Tranſparency depends on the Fineneſs or Smallneſs of the Pores, and ſolid Parts; and Opacity on their being large. —— Thus Paper having its Pores filled with Oil, becomes much more tranſparent, than it naturally is, when filled with Air.

Euphroſ. I fancy ſome of thoſe Experiments, which you ſhewed me, relating to the Production of artificial Air, would ſhew themſelves to great Advantage in the exhauſted Receiver.

Cleon. In this you would find yourſelf miſtaken, were you to try them all; for the Rarifaction of the Air, in many of them, would be ſo violent, as to drive the Liquor out of the

We think proper, by way of Note, to give the following Account of two Air-pumps contained in Plate the XXXth.

A *Deſcription* of the Structure of *Davenport*'s Air-pump.

a a The Braſs Barrels.
c c The Piſtons.
d d The Braſs Knobs, which ſcrew down the Bed of the Pump upon
e e The Pillars.
f f The Braſs Pipe communicating with
h h The Receiver above, and
l l A Pipe below, from whence the Air is conveyed to the Barrels.
i i Is a Braſs Wire, ſliding through a Collar of Leathers, on the Top of the Receiver.
k The *Mercurial* Gage on the lower Part of the Pump, with which the Pipe *l l* alſo communicates.
m Is the Stop-cock, to be turned for letting in the Air.

This, together with the foregoing Deſcription of the large ſtanding Pump, is ſufficient to ſhew the general Mechaniſm of this Machine; but as in both theſe, the Structure is very complicated, I have contrived one, in a much more ſimple and portable Form; and therefore I have called it the *Portable Air-pump*, and have ſhewn it, by a proper Figure, in the lower Part of Plate XXX, of which no *particular Diſcription* is neceſſary; as the Parts of which it conſiſts are ſo few, and fully deſcribed already in the other Pumps; eſpecially, as it has been ſo many Years known, and approved of by the Public.

Veſſels.———This happens, eſpecially in effervefcent Liquors, or Acids and Alkalies mixed together. ——— Some of theſe Liquors being mixed in the exhauſted Receiver, produce ſuch an exploſive Æther, or Spirit, as to blow up the Receiver from the Pump, notwithſtanding the great Preſſure of external Air upon it.———Such Experiments, therefore, as they are not to be ſhewn without Danger to the Perſons preſent, I ſhall not attempt, but the following one is very innocent, and will ſhew the Nature of metalic Solutions more perfectly than you can ſee it without. ——— I take a Quantity of *Aqua Fortis*, a little warmed, and put it in a ſmall Jar under the Receiver.——— On the Top of the Receiver, a Braſs Wire is moved up and down, thro' a Collar of Leathers at Pleaſure. ——— Then, before I turn the Winch, I thruſt the Wire down about an Inch into the Fluid, and a gentle Solution begins, with a conſiderable Production of Air; ——— but obſerve, when I turn the Winch, how ſurpriſingly theſe Bubbles of Air increaſe, and what a prodigious Effervefcence they occaſion in the Liquor. This is only an Illuſtration of the general Nature of Solution, in which we obſerve the Body is reſolved into two Parts, *viz.* its own metalic Part, and a large Quantity of Air.

Euphroſ. But the Air which I now ſee is the factitious, or generated Air, from the Body itſelf. The Air contained in the Pores of ſolid Bodies is likewiſe rendered viſible, I ſuppoſe, as you intimated juſt now.

Cleon. It is very eaſily extracted, and ſhewn this Way, by placing the Body under Water. ——— Thus I take this Piece of Free-ſtone, and a Piece of Braſs, and put them both in the Water of the Jar, and by pumping the Air out of the Receiver, it riſes by Degrees from the Pores of thoſe Bodies; and when I have pumped long, the whole Surface of the Braſs and Stone is nearly covered with thoſe pearly Bubbles of Air, which make a very curious Appearance; and the like you would obſerve from any other common, earthy Subſtance.

Euphroſ. As alſo, I ſuppoſe, from any animal, or vegetative Subſtances.

Cleon. They contain much greater Quantities of Air; ſome Specimens of which, I ſhall now give you. ——— I take this new-laid Egg, and put it in the Jar of Water under the Receiver, and upon turning the Winch,——you ſee many fine Streams of Air riſing from the Pores of the Egg. —— As I continue to work the Pump, you ſee many more of theſe äerial Jets ariſe.——Obſerve now the Pores of the Egg emitting the Air in innumerable ſmall Bubbles, which gives it a very pleaſant Appearance ——After this, as the *Vacuum* proceeds, you find the Egg expanded by the Rarifaction of the internal Air, ſo as to be rendered ſpecifically lighter than it was. —— You ſee it move, and roll about, and ſeems, as it were, to endeavour to riſe to the Top, and is therefore but very little heavier than Water. —— I turn the Cock, and let the Air in, and you ſee the Streams and Bubbles all diſappear at once.

Euphroſ. Theſe Things are extremely entertaining. I could not have imagined there could have been ſo much Air contained in an Egg, or, that there had been ſuch evident Pores in the Shell.——I ſuppoſe, that, in like Manner, if a whole Animal were to be immers'd, one might ſee the Air iſſue from the Pores of his Skin.

Cleon. That may be eaſily experimented in a ſmall Bird, plucked of its Feathers, and put under Water.——In vegetable Subſtances of every Kind theſe Experiments ſhew a ſurprizing Quantity of Air, as I ſhall inſtance in this Apple, that is juſt now gathered from the Tree.——I connect it with a Piece of Braſs, and ſink it to the Bottom of the Water, having firſt made a few Holes in it with a Pin.——Then I cover it with a Glaſs, and as I begin to exhauſt, you ſee the Air ariſe from the different Parts of the Apple, but particularly from the Holes made with the Pin.——As I further proceed, you ſee the Air riſing from the Pores of the Apple in many ſenſible Streams. —— As the Air is ſtill farther rarified, the Streams are more and more numerous, and the Quantity of Air ſo great, as to make a perfect Ebullition on the Top of the Water. —— If the *Vacuum* remain for any Time, you will ſee the Bubbles and Streams of Air continue ſo long, —— and if you look at the Gage, you will ſee the Mercury ſink in Proportion to the Air, produced from the Apple, and this as often as the Experiment is repeated. —— At laſt I turn the Vent-ſcrew, and the Air diſappears at once.

Euphroſ. This is a noble Experiment, truly! and I ſancy, from what I have now obſerved, that a ſhrivelled Apple would alſo make a very pretty Appearance in the Water.

Cleon. It will, indeed; and I uſually ſhew the Experiments on both, when they can be had.——I have a withered Apple of the beſt Kind for this Purpoſe, which I ſhall now put into the Water, and you will ſee the Difference between this and the other.——When turning the Winch, you ſee many Streams of Air ariſe, tho' not ſo large and numerous as before; but you obſerve, at the ſame Time, the Effect of the internal Air, by expanding the Apple, and cauſing the Wrinkles to diſappear by Degrees,——till at laſt, it has attained to the full Extent of its Skin, and looks nearly as full and freſh, as when firſt gathered from the Tree.

Euphroſ. By this Experiment and the Former, I am thoroughly convinced of the Nature and Difference of Fruit, with regard to the Air they contain. I ſee from thence, how pervious they are to this neceſſary Element. I learn too from hence, how neceſſary the Air is to preſerve them, and to give them that Poignancy and pleaſant Flavour, which they have when recent or freſh gathered; and that Mellowneſs, and Rotenneſs, proceed, from ſome Deficiency either in Quantity or Quality of the Air in Fruit of the laſt Year's Growth.

Cleon. You reaſon very well on the Experiments you have ſeen; but, by another Experiment or two that will follow, you will find, that Fruit of any Kind is beſt preſerved without any Air at all; and that it is the conſtant Action of the Air that deſtroys the natural Texture by an inceſſant and inſenſible Fermentation in the Parts, which diſpoſes them, by very ſlow Degrees, to become putrid, or rotten.

Euphroſ. If this be the Caſe, one would think Methods might be contrived, by Means of your Pump, to keep the Fruit from the Air as long as you pleaſe, which would be a fine Improvement for the Paſtry-cooks, in regard to their Tarts and Pies.

Cleon. It would ſo; and in an Age or two more, our Poſterity may wonder how it came to paſs, that the great Philoſophers of this Age ſhould ſhew ſo bad a Taſte, and be content with diſcovering the Means of living well, but leaving them to enjoy it. You will find Mr. *Boyle*'s Works abound with Inſtances of this philoſophical Method of preſerving Fruit; many of which, if we may judge from his Experiments, far exceed the poor Proviſion of Pickles and Confections.

Euphroſ. You make me very attentive to what you now ſay. This is a very intereſting Point with me, and I muſt inſiſt upon your being extremely particular in gratifying my Curioſity and Enquiries upon this Head; and, in the firſt Place, pray, tell me how you proceed in this Affair of preſerving Fruit.

Cleon. For this Purpoſe, we have Glaſſes, blown of a proper Form, to hold a Pint, or Quart, or any Quantity you pleaſe, of any Kind of Fruit; as Peaches, Nectarines, Apricots, Apples, Pears, Plumbs, Cherries, Gooſeberries, Currants, *&c.* The Mouth, or Neck, of theſe Bottles is therefore larger or ſmaller, in proportion to the Size of the Fruit you intend to preſerve, and their Form muſt be conical, or tapering inwards.——In the next Place, Corks muſt be nicely fitted to the Orifices of theſe Glaſſes. Then, having filled the Bottle with Fruit, clean and dry, you put in the Cork, and tie a wetted Bladder over it, ſo that, when dry, it may firmly adhere to the Cork and the Glaſs, and by this Means render the whole Air-tight. —— After this, you place Sealing-wax on one Part of the Cork, and with a red hot Iron Wire burn a Hole through the ſame, that thereby a Paſſage may be given for the Air to be drawn out from the Fruit.

Euphroſ. Such an Experiment I ſhould be extremely glad to ſee. Have you got any ſuch Glaſs by you, *Cleonicus?* If you have, I can ſupply you with Fruit.

Cleon. I have ſeveral of them, and your Garden produces ſome of the fineſt Fruit to be preſerved in this Way. A few of your Nectarines and Peaches, gathered dry, will ſuffice for an Experiment at preſent, and afterwards you may make uſe of this Procedure for any other Sort or Quantity of Fruit you pleaſe.

Euphroſ. I will, this Minute, ſtep into the Garden.—— Did you ever ſee finer Fruit? —— Where is your Glaſs? Have you one that will take any Fruit ſo large?

Cleon. This one will do it, and was made for receiving this Sort of Fruit. What you have brought are fine indeed; but you will find, that the Age of Fruit will little appear in their Countenance in *February* next.———You obſerve, I carefully put them into the Glaſs till it is filled:———Then, this Cork, prepared, readily fits the Top of the Recipient, which I preſs down very hard.——— Then, with this ignited Wire, I burn a Hole through the Sealing wax and Cork; and here I muſt ceaſe from purſuing this Experiment any farther at preſent; the Sun muſt lend us his Aid, and co-operate in the enſuing Part. Beſides that, I have already tired your Attention with ſo long a Lecture. To-morrow, if the Morning be clear, as ſoon as the Sun-beams enliven the Parlour, I ſhall then wait on that glorious Luminary and yourſelf; ſo at this Time, Adieu.

DIALOGUE XII.

The Experiments *on the* AIR-PUMP *continued.*

Euphroſyne.

THIS Morning anſwers to my Wiſhes; the glorious Sun promiſes Succeſs to our Deſigns, and the Entertainment you gave me with the preceding Experiments, have greatly excited my Expectations for the Remainder; but none takes with my Curioſity ſo much, as the *Experiment* under Conſideration.———I ſee here ſtands the Bottle with the Fruit ſtill.

Cleon. Yes, and in a few Minutes time the Sun will dart its Beams into the Room. ——— This convex Glaſs will converge the Beams of the Sun into ſo ſmall a Compaſs, as to make them burn any combuſtible Object that is placed in the denſer Part, or the Focus in the Rays.———Thus, you ſee, I hold the Glaſs in the Sun-beams, and a Piece of brown Paper in the Focus.———You ſee it begins to fume,———and immediately kindles into a Flame.

Euphroſ. A ſurpriſing Experiment indeed! The Heat that ſets that Paper on fire, will certainly melt the Wax on the Cork, which now, I preſume, you are ready for.

Cleon. I waited only for the Sun, and now I take the Pump, and place it in its Beams,——and exhauſt the Air from the Fruit.——Then, with the Glaſs, you ſee, the Sun-beams are eaſily thrown on the Wax, which inſtantly melts, and cloſes up the Hole;——and now is your Fruit prepared for keeping at your Pleaſure.

Euphroſ. I thank you, *Cleonicus*, for this. I ſhall ſet it by, with an Intent to prove how far your philoſophical Diſcoveries can be applied to improve thoſe natural Delicacies of Life. ——I am afraid I have detained you too long with this Experiment. Pray, what have you next to follow?

Cleon. As theſe Experiments are deſigned to illuſtrate the Properties of natural Bodies, with regard to Air, I ſhall now entertain you with one or two more, about vegetable Subſtances; and you muſt know, that Plants are organized Bodies, or conſiſt of Veſſels, of different Kinds, for circulating Fluids from the Earth and Air, through all the Parts; for they, no more than Animals, can ſubſiſt without a conſtant Reſpiration of Air.——Many Experiments we ſhall hereafter ſhew, to demonſtrate this; but at preſent ſhall entertain you with one or two on the Pump.——You ſee, I have a long Piece of Wood, fixed into a Socket of Braſs:——This I place on the open Receiver, ſo that the lower End is immerſed in a ſmall Jar of Water,——and exhauſting the Air from the Surface of the Water, you ſee how plentifully it ruſhes through the Veſſels of the Wood to ſupply the Deficiency.——I put my Thumb on the upper Part of the Wood, and you ſee no more Air appear through the Water.——When I take off my Thumb, you again ſee the Air ruſhing through the Pores of the Wood into the Water; and thus alternately, as I put my Thumb on or off.——By this Experiment, you ſee, that any Piece of Wood is pervious to the Air, and that thoſe Air-veſſels run through the whole Length, or Subſtance of the Tree.

Euphroſ. This is a very pleaſant Experiment, and entertains the Eye, at the ſame Time as it improves the Mind. I knew not before, that Air was ſuch a neceſſary Article in Plants, or that they were thus conſtructed, to circulate that wonderful Fluid.

Cleon. But I have yet another Way to ſhew the ſame Thing, which, for Variety-ſake, I ſhall next entertain you with.——I take a Piece of the ſame Wood, about half an Inch long, cemented in the lower Part of a hollow Cylinder of *Lignum Vitæ*, which, when placed on the Top of the open Receiver, I fill with a Quantity of *Mercury*; and now, exhauſting the Air from beneath the Weight of the Air, on the Top of the Quick-ſilver, forces it through the Pores of the Wood, and makes it deſcend into a ſmall Glaſs below, in the Form of a Shower of Rain.

Euphroſ. A moſt beautiful Shower of *Mercurial* Rain, indeed! my Eyes ſcarce ever beheld any Thing more agreeable. ——It continues to rain in an uniform, ſteady Manner.——A tranquil Shower truly! for though I plainly ſee it, yet I can ſcarcely hear it at all. ——But ſee, it ſtops at once, and all the *Mercury* diſappears above the Wood.——Well! this is a thorough Demonſtration of the Poroſity of the Wood, indeed.

Cleon. You are ſatisfied in this Point by the foregoing Experiments; but what if I ſhould entertain you with one more yet to the ſame Purpoſe?

Euphroſ. You will then ſtill more delight me, and I ſhould be glad to ſee ſo important a Doctrine eſtabliſhed and confirmed by every Way you think proper; ſince every Experiment is at the ſame Time a new Recreation.

Cleon. The Pores of Wood, which you have already ſeen pervious to the Air and *Mercury*, I ſhall next fill with the Latter of thoſe Fluids,——and ſhall ſhew you this Piece of Wood entirely altered, in regard to its Colour and Weight. It is now a light Subſtance, and will ſwim in Water; you will then find it heavy enough to ſink to the Bottom, like a Stone. The Colour is now white; but when injected with Quick-ſilver, it will be changed to a darkiſh Hue.——To this End, I put it, under a Quantity of *Mercury*, in a ſmall Glaſs, and there confine it with a Cork.——I then exhauſt the Air from the Receiver, placed over it, and the Air, contained in the Pores of the Wood, throws itſelf out, as you plainly ſee from each End, through the Quick-ſilver.——It is now quite exhauſted, and by letting in the Air again, it falls on the Surface of the Quick-ſilver,

ſilver; and forces it into every Pore of the Wood.——Here it is; pray, take it in your Hand, and look at it.

Euphroſ. Well, it is ſtrangely metamorphoſed indeed! It looks now of a blue Colour, and is ſurpriſingly heavy; ſure there muſt be a large Quantity of *Mercury* to make it ſo.

Cleon. There is, indeed, a great deal of *Mercury* contained in the Wood, and —— if I ſtrike it againſt the Table, you ſee a great Quantity falls out of the Pores. —— By weighing the Wood before, and after it is injected, you will find the Weight of Silver it contains:——But what will afford you the moſt pleaſing Idea is, to view the Wood, thus filled with *Mercury*, with this magnifying Glaſs.

Euphroſ. A moſt delightful View it affords, indeed! I ſee the Quick-ſilver in each Pore beautifully round, and ſhining, like ſo many Pearls, all over the Surface of the Wood.—— It muſt certainly be owing to People's not being acquainted with the Nature of theſe Things, that they appear ſo indifferent, with regard to theſe ſublime, and rational Amuſements, and ſubſtitute the low Diverſions ſo much in vogue for their leiſure-hours Employments. —— But, pray, *Cleonicus*, what mean theſe *Satyrs*, and other Kind of Figures, which I ſee at the Bottom of this Jar of Water?

Cleon. They are intended to exhibit an entertaining Spectacle to the Eye; for, when I place them under the Receiver, and exhauſt the Air,——you obſerve, they gradually aſcend one after another. —— Firſt, the Bubble aſcends to the Top of the Water, —— the *Satyr* turning himſelf about, with his cloven Foot, aſcends perpendicular to the upper Regions of the Fluid.——After this, the other antique Figures begin to move, and, in their Turns, aſcend to the Top of the Fluid, ——And laſtly, *Lucifer*, with his Pitch fork, aſcends in the Rear, from his *infernal* Station.——

Euphroſ. They make a groteſque Figure, truly! under the Surface of the Water. They ſeem ſuſpended and moved, like the Puppets in a Shew: —— But I ſee the Magic of all theſe Movements plainly; the Images, which are all of them heavier than Water, and ſome more ſo than others, and therefore ſink to the Bottom of the Water; —— but their Bodies being hollow, and filled Part with Water, and Part with Air, thro' ſmall Holes in the lower Part, it neceſſarily follows, that, when you pump the Air out of the Receiver, that in the Body of the Images will expand, and expel ſome of the Water, 'till, by this Means, each Image is rendered lighter than the Water; and conſequently, muſt aſcend to the Top, in that pleaſant Manner we behold them.

Cleon. That is the very Thing, my *Euphroſyne*; and if I ſhew you the Experiment, I find, it is ſufficient; you ſave me the Trouble of an Explication. ——— It will not be amiſs, in the next Place, to ſhew, by Experiment, that the Medium of Air does neither help nor hinder the attracting Forces of Bodies one upon another; which I ſhall prove in the three different Caſes of Magnetiſm, Electricity, and the Attraction of Coheſion. ——— And firſt, I place this ſmall Compaſs and Needle under the Receiver; ——— then, by applying one End of the Magnet,

An Explanation of the Figures, repreſenting the Experiments of the Air-pump, in Plate, N°. XXXI.

Fig. 1. Shews a ſmall Glaſs, fixed upon the Plate of the Air-pump, by the Weight of the Air.

2. The Glaſs Bubble, exhauſted of Air, and filled with Water.

3. The ſame Bubble, having its Water exhauſted, and afterwards filled with Air.

4. The Air, in the great End of an Egg, driving the Yolk out of a Hole at the little End.

5. Half the Egg-ſhell taken off, to ſhew the *Putamen*, or Skin of the Egg, raiſed up and protruded from the Egg, by the Expanſion of the Air within.

6. The Air-bubble copiouſly aſcending thro' the Water, from the Pores of the Egg.

7. Shews the Air, ariſing from the Pores of an Apple, ſunk to the Bottom of a Jar of Water.

8. Shews a Bladder, which at firſt contained but very little Air, and its Neck faſt tied, expanded by the Spring of the internal Air, nearly to its full Dimenſions.

9. Shews an empty Bladder, ſunk to the Bottom of a Jar of Water, by a Weight, which is afterwards raiſed to the Top, by the Expanſion of the Air in the Bladder.

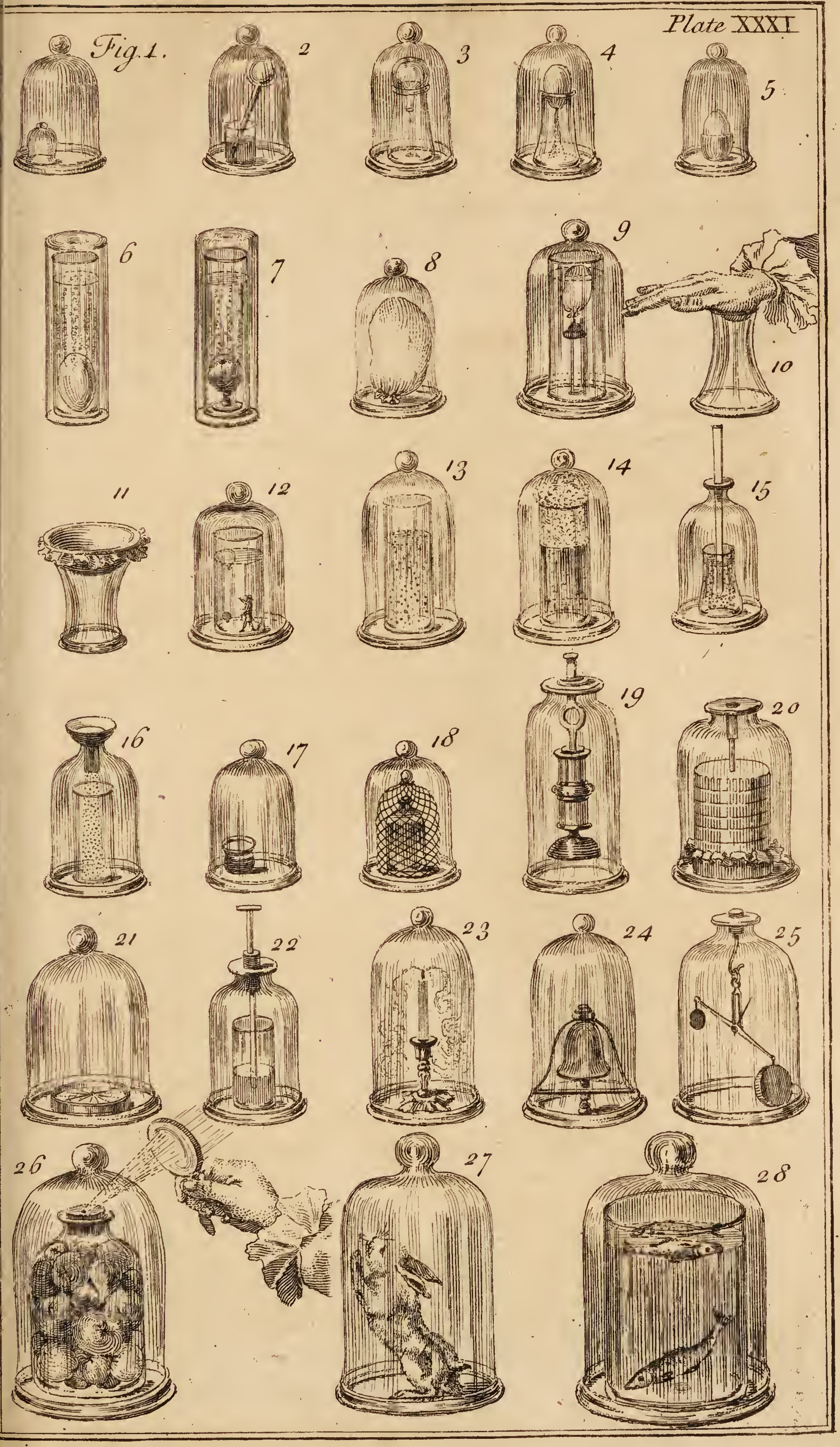
10. Shews the Reaſon of Cupping, by placing the Hand on the Top of an open Receiver.

11. The Weight of the Air breaking a Bladder, (tied on a proper Glaſs) by its Preſſure.

12. Small Glaſs-bubbles, and Images, raiſed from the Bottom of a Jar of Water, in *Vacuo*.

13. Shews

EXPERIMENTS on the AIR PUMP



Magnet, it attracts one End of the Needle; but, if I turn the other magnetic Pole, it repels this, and attracts the contrary End of the Needle, juſt in the ſame Manner *in Vacuo*, as in the Air.

Euphroſ. It certainly does: The Needle is put into Motion with the ſame Eaſe in one Caſe, as in the other; at leaſt, I can ſee no Difference. ——But what ſeems moſt wonderful, is, that the magnetic Virtue ſhould not be interrupted by the Glaſs. I ſhould have thought, it would have proved a very ſenſible Obſtruction to the Influence of the Magnet.

Cleon. Not in the leaſt, this Virtue is of ſuch a ſurpriſing Nature, that it penetrates thro' any Sort of Subſtance, excepting Iron, with ſcarce any ſenſible Dimunition of its Force, as I ſhall more particularly ſhew you hereafter, when we come to conſider the Nature and Properties of this extraordinary Foſſil.

13. Shews the Air contained in Water.
14. The Air in Beer, riſing into a frothy Head.
15. The Air, paſſing thro' a long Piece of Wood, render'd viſible in Water.
16. Shews the Quick-ſilver, forced thro' the Pores of Wood, and deſcending, in the Form of a *Mercurial* Shower, into a Glaſs Jar below.
17. A Piece of Wood, immers'd in Quick-ſilver, to have its Pores injected therewith.
18. Shews a ſquare Glaſs broke by the Spring, or Preſſure of the Air.
19. Shews the Syringe deſcending by the Weight at Bottom, by the ſuſpended Piſton.
20. Several heavy Weights raiſed by the Expanſion of Air in an empty Bladder under them.
21. Shews the Motion of a *magnetic* Needle in *Vacuo*, by a Loadſtone externally applied.
22. A capillary Tube, immers'd in Water, to ſhew the Riſing of that Fluid by Attraction, in *Vacuo*.
23. Shews the Candle going out, and the Smoak deſcending in the exhauſted Receiver.
24. Shews the Air to be neceſſary for conveying Sound, by the ringing of a Bell, in *Vacuo*.
25. Shews the different Weights of Bodies in the Air, and in *Vacuo*.
26. Shews the Method of preſerving Fruit, by exhauſting the Air, and preventing its Return.
27. Shews the Air to be neceſſary for animal Life.
28. Shews Fiſhes are unable to abide at the Bottom of the Water, by reaſon of the Expanſion of Air in their Bladders, and the Increaſe of their Bulk by that Means.

——— Then, as to the electrical Fluid, the Glaſs does no way obſtruct its Action; for, if I take thoſe ſmall Pieces of Leaf-ſilver, downy Feather, *&c.* and place them under the Receiver, and draw out the Air; ———then, you obſerve, by applying the excited Tube to the Side of the Recipient, the light Bodies will be attracted and repelled, in the ſame Manner as in the Air.

Euphroſ. It is certainly Fact. Neither the Glaſs, nor a *Vacuum* impedes the Action of this wonderful Power; which Thing I could not readily have imagined, if theſe Experiments had not verified it to my Sight.

Cleon. Then, as to the attracting Force of Bodies in general, it is the ſame in *Vacuo* as in the Air, which I thus demonſtrate: ——— You ſee, this capillary Tube, being immerſed with one End in Water, attracts that Fluid to the Height of one Inch within its narrow Bore above the Surface, and it will produce the ſame Effect, if it be immerſed in the Water in *Vacuo.*———To this End, you ſee, a particular Apparatus is provided, in which the ſame capillary Tube is placed at a Diſtance, above the Water in the Receiver: ——— Then, having drawn out the Air, I thruſt down the Wire, ſo that one End of the Tube deſcends into the Water, and you ſee, that the Water is inſtantly attracted, and riſes to the ſame Height in the Tube as before.

Euphroſ. I plainly ſee it does; and from all theſe Experiments, I am thoroughly convinced, that the Powers of Nature are very wonderful. Bodies act upon Bodies with a penetrating Efficacy, in a Manner, too wonderful to be conceived or underſtood, without the Aſſiſtance of Philoſophy.

Cleon. We ſhall now change the Scene for the following Act, and divert you a while with breaking of Bottles, by which the Weight and Spring of the Air will be farther demonſtrated, and that their Effects are always equal to each other. For this Purpoſe, you ſee provided a Sort of Bottles, blown thin, and of a ſquare Form, that the Air may have a greater Force on its flat Sides to break them. ——— On the Top of one is cemented a braſs Cap, perforated thro' and over the Hole is tied a ſmall Piece of Bladder for a Valve, which admits a Paſſage out of the Bottle into the Receiver; but prevents its Return. ——— Then, placing the ſaid Glaſs on the Pump, under the Wire-cage, I place over all the Receiver. ———And now obſerve, that having exhauſted the Air from the Receiver, and conſequently from the Bottle, as it cannot return into the ſaid Bottle, when I turn the Stop-cock, it muſt fall round about it, and by its Weight and Preſſure, it cruſhes the Bottle to Atoms; as you ſee.

Euphroſ. Yes truly, I ſaw, and heard it both; and the ſudden Effect made me ſtart. ———I ſee from hence, how greatly the Form of a Glaſs prevents it from ſuffering by the deſtructive Preſſure of the Atmoſphere, and that a ſpherical and cylindric Form is neceſſary for the Receivers you uſe, to fortify them againſt ſo great an external Force.

Cleon. What you obſerve is very true; and I have heretofore mentioned to you the great Effects of confined Air, in burſting Bottles of Beer, Wine, *&c.* and ſhall now give you an Experiment of the ſame Kind upon the Air-pump. In this other ſquare Bottle, the Air, which is confined by the Cork and Cement on the Top, ſo that, when it is placed under the Gage on the Receiver, and the Air begins to be exhauſted, you will obſerve the Effect;———for, upon turning the Winch, I exhauſt the Air gradually, and leſſen its Preſſure upon the Glaſs; but the Spring of the Air remaining, the ſame in the Bottle will at length prove ſuperior to the Coheſion of the Glaſs, and Compreſs-force of the external Air, ——— which muſt neceſſarily burſt it, as you ſee.

Euphroſ. I did not expect it quite ſo ſoon, but I conſider the Bottles are very thin; and, if they were thicker, I ſuppoſe, the Effect would be too violent for an Experiment.

Cleon. That is the Caſe in all Experiments of a ſtriking and ſurpriſing Nature. We take care to employ no more Force than what is neceſſary to anſwer the Purpoſe the Experiment is intended for.———As by many of theſe Experiments you have been taught, how great the Weight of the Air is, upon the Whole, I ſhall next ſhew you, that the Weight of this Fluid is very ſenſible in ſmall Quantities, and that it may be weighed in a Balance, in the ſame Manner as any other Body is.

Euphroſ. This will be certainly a moſt agreeable Experiment! But I have not the leaſt Notion how, or which Way that is to be done.

Cleon. You will find it is very eaſily performed, in the following Manner.——I have provided this *Florence* Flaſk, and cemented a Cap of thin Braſs on the Top of it, with a ſmall Hole in it, over which a Piece of Bladder is tied for a Valve; this will admit the Air to be drawn out of the Bottle; and prevent its re-entering, as you ſaw before. —— This Flaſk I now place under the Receiver, and exhauſt all the Air out of it.——Then, you obſerve, I let in the Air, and the Flaſk is not broke, by reaſon of the great Strength of this Kind of Glaſs, and its ſpherical Figure. —— But the Air being exhauſted, I hang it on the End of a Balance, and equipoiſe it with Weights in the oppoſite Scale: —— Now liſten attentively, and when I lift up the Bladder-valve with a Pin, you will hear the Air ruſh into the Flaſk:——And now, you ſee the Flaſk preponderates the Weight of the Scale, and goes down. —— Then I put ſo many Grain-weights in the other Scale, as reſtore the Equilibrium, and conſequently, ſhew the Weight of the Air contained in the Bottle.

Euphroſ. This Experiment is really very curious, and confirms the old Saying, "That every Thing is eaſy, when it is "underſtood." I ſhould have thought it a more difficult and critical Matter to have weighed Air in a common Balance; but to my Surpriſe, I ſee you make no more of it, than a Grocer does to weigh a Pound of Sugar. —— One Thing you muſt let me know, *viz.* how many Grains you put into the Scale to balance the Weight of the Air.

Cleon. Juſt *ten Grains*, and the Bottle, when nicely meaſured, will be found to hold one Pint and a Quarter; ſo that it follows from hence, that a Pint of Air weighs *eight Grains*, and conſequently, a *Gallon of Air weighs* 64 Grains, which is a little more than a *Dram*; therefore a *Buſhel of Air* will weigh a ſmall Matter more than eight Drams and a Half, or an *Ounce and Half a Dram*; by which you may eaſily underſtand what the Weight of the Air ſhall be in any other Bulk.

Euphroſ. Very eaſily, truly; you have, by this Experiment, given my Thoughts quite a new Turn, with reſpect to the

Weight of the Air, which I had no Notion of being ſo very ſenſible in ſmall Quantities, as you have made it appear.—— But what is intended by this Syringe, with a Leaden Weight at the End of it?

Cleon. I will tell you; the Syringe has its Piſton, different from that of a common Syringe, as it has no Valve, or Hole thro' it. This Piſton, therefore, being placed at the Bottom of the Syringe, and the leaden Weight, ſcrewed on the Outſide with a Piece of Leather, to prevent any Air getting in; then, when the Piſton is raiſed, it muſt lift up the Column of Air above it, and conſequently, make a *Vacuum*, in a great Meaſure, below. —— I let go the Piſton, and it flies, with great Rapidity to the Bottom, by the Force of the Air's Preſſure on it, by which you underſtand, that the Piſton and the Syringe are firmly kept together by the Preſſure of the external Air; and conſequently, if this Piſton be ſuſpended on the Hook of the Braſs-plate, placed on the Top of an open Recipient; then, upon exhauſting the Air, and leſſening its Force on the Syringe, the Weight of the Lead will cauſe the Syringe to deſcend from the Piſton, and lower, in Proportion, as the Air is more exhauſted.——You ſee the Experiment.

Euphroſ. I do; and it pleaſes me much, that I can, at the ſame Time, ſee the Reaſon of it; and I further perceive, that, when you let the Air in again, it muſt force the Syringe up to the Piſton again.

Cleon. That will be the Caſe. —— I turn the Vent-ſcrew, and the Syringe returns, in a Moment, to the Piſton.

Euphroſ. But theſe great Weights in a Box, which I ſee ſtanding here! What Kind of Experiment do you ſhew with them?

Cleon. Still ſomething of the ſame Purpoſe, *viz.* to ſhew the great Spring of the Air in any very ſmall Quantity.—— For taking the Weights out of the Box, you there obſerve, at the Bottom, a Bladder, in Appearance, without any Air; yet a ſmall Quantity there is in it, which will be found ſufficient to raiſe all thoſe heavy Weights, by the Force of its Spring, when the Air is exhauſted from the Receiver, placed over it. Obſerve the Experiment. —— I place the Weights on the Bladder in the Box, and with the firſt Turn of the Winch, you may juſt perceive them begin to riſe. ——— The next Turn of the Winch makes the Air expand, and they riſe more ſenſibly by the Side of the Veſſel. ——— As I proceed in exhauſting the Air, you ſee they continue to riſe, till at length, they have riſen more than an Inch higher above the Rim of the Box, than they were at firſt.———Hence you ſee how great a Force the Spring of that ſmall Quantity of Air muſt be.

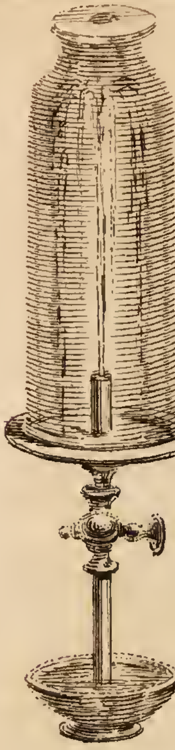
Euphroſ. One would hardly imagine, when one ſees an empty Bladder, that there ſhould be ſo great a Force concealed in it: Such Things would never gain Credit by bare Report, if they were not verified by Experiment. ——— One Thing has long taken my Eye in this miſcellaneous Apparatus, and that is, the Guinea and large Piece of Cork, which I ſee appended to that fine Balance; but, I think, they ſeem not to be nicely equated in Weight, as the Gold appears to preponderate the Cork.———I ſuppoſe you have ſome intereſting Point to eſtabliſh by an Experiment thereby.

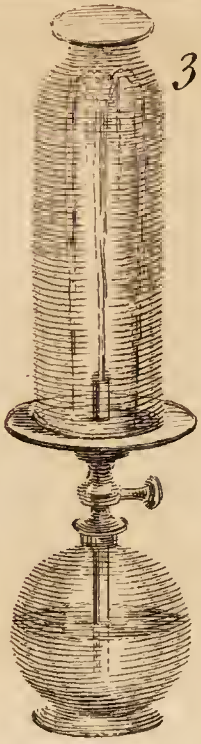
Cleon. A very material Circumſtance of Statics depends upon this Experiment, which is intended to ſhew, that, when this Balance, with a Guinea and Cork, is ſuſpended in the Receiver, that then the Cork, which now ſeems lighteſt, will then prove the heavier Body, and much preponderate the Guinea. I ſhall ſhew you the Experiment firſt. ——— To the Hook of the Braſs-plate, I hang the Balance within the Receiver, and place it on the Pump.———Then, obſerve, that, by the firſt Turn of the Winch, there is a perfect Equilibrium between the Cork and the Guinea.———In two or three Turns more, you ſee the Cork manifeſt a greater Weight than the Gold, by its deſtroying the Equilibrium. ——— And when I have taken the Air quite away, you ſee the Cork preponderate the Gold, as far as the Beam will admit.

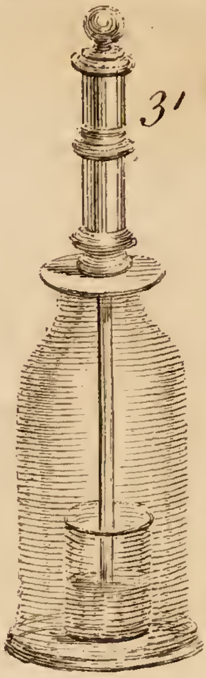
Euphroſ. This is certainly a very ſurpriſing Experiment. ——— I could not have imagined ſo great a Difference in the Weight of Bodies could have been occaſioned by the Medium of Air; and tho' I know it is occaſioned by the Air, I have not yet Philoſophy enough to ſee thoroughly the Reaſon of it; in which Caſe, *Cleonicus*, I muſt beg your Aſſiſtance for a clear Apprehenſion of this Matter.

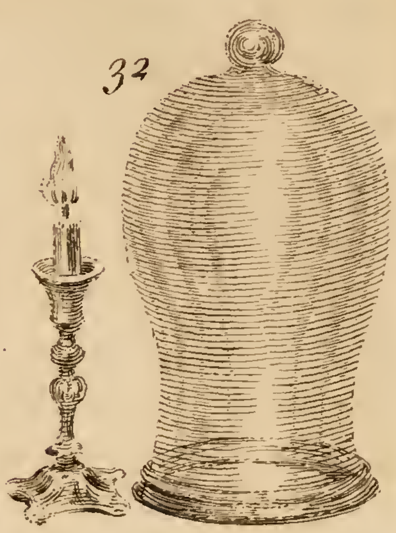
EXPERIMENTS on the AIR PUMP.

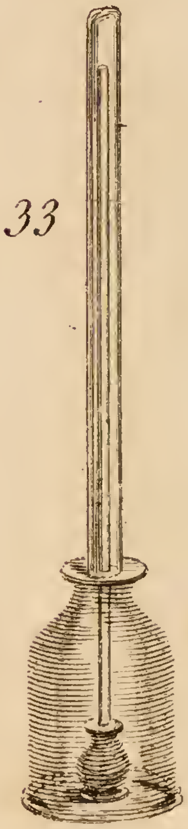
Plate XXXII.

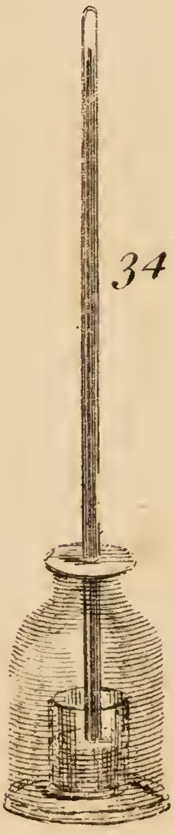


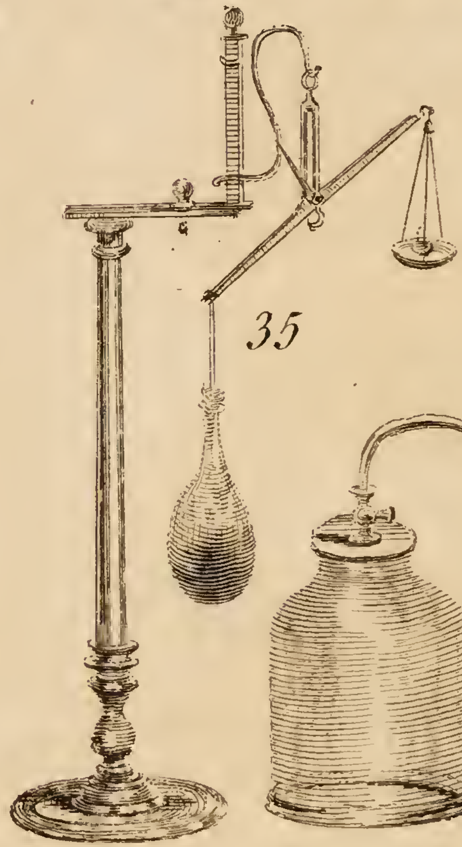


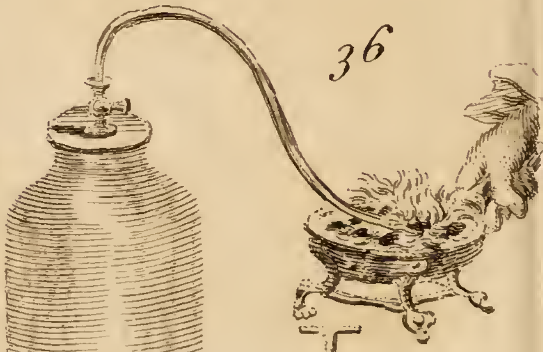


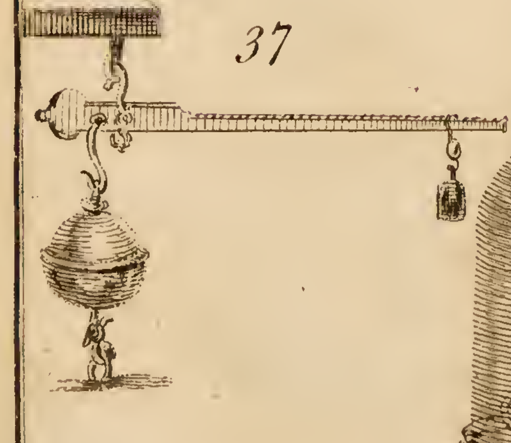


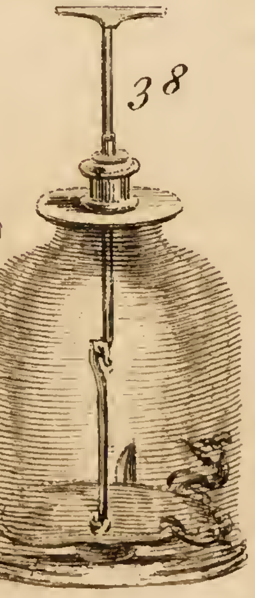


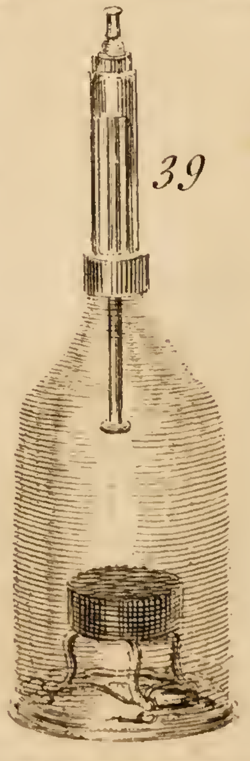


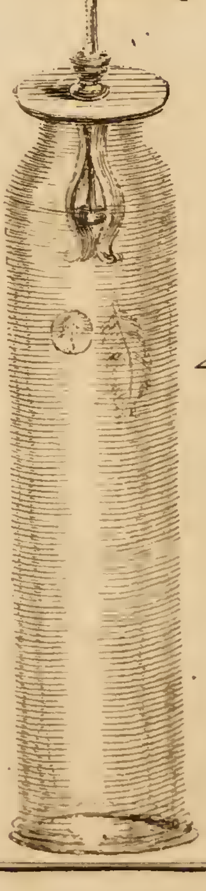












Cleon. You will hereafter ſee many Experiments to prove, that Bodies, moving in a Fluid, meet with Reſiſtance from it, and that in Proportion more, as their Bulk are larger in equal Weight. ——— The Air is a Fluid, and the Cork of equal Weight with the Guinea, being many Times larger in Bulk, will meet in Proportion, with ſo much more Reſiſtance from the Air; this Reſiſtance will therefore oppoſe the Deſcent of the Cork, more than it does that of the Metal; and conſequently, will diminiſh more of its Weight in a greater Degree. Therefore, when the Weights of thoſe two Bodies are equal in the Air, it muſt follow, that, when the Air is taken away from the Recipient, the larger Bulk of Cork, which before was moſt reſiſted, will now prove the heavier Body; as you ſee in the Experiment; and hence it has happened, that a Hint from this Experiment, has put ſome of our ſaving Connoiſſeurs upon inſpecting their Barometers, to learn from thence, the Denſity of the Air, when they propoſe to purchaſe precious Stones, or Things of great Value, ſold by Weight, which are heavieſt in the lighteſt Air.———Alſo, from this Experiment it appears, that a *common Pound of Feathers* is really heavier than *a Pound of Lead*, contrary to what is imply'd by the uſual Catch.

An Explanation of the Figures, repreſenting the Experiments in the Air-Pump, in Plate XXXII.

Fig. 29. A Fountain playing in an exhauſted Receiver by the Preſſure of Air.

30. Ditto by the Spring of the Air.

31. An Experiment, ſhewing the Rationale of Pump-work.

32. Shews the Manner how Halos are produced about a Candle.

33. Shews the Aſcent of Quick-ſilver in a Tube, by the Spring of the Air.

34. Shews the ſame by the Preſſure of the Air.

35. The Experiment of weighing Air in a Bottle.

36. ————— of burnt Air by a Charcoal Fire.

37. ————— of the exhauſted Hemiſpheres applied to the Stilyard.

38. ————— of a Gun-Lock in Vacuo.

39. ————— of Gun-powder not firing in Vacuo.

40. ————— of a Guinea and Feather falling together in Vacuo.

Euphroſ. Theſe Experiments ſhew the Uſe of Philoſophy to Mankind, in rectifying our vulgar, and oftentimes, miſtaken Notions of Things.

Cleon. The Truth, which you have now mentioned, will be farther confirmed by the next Experiment. ——— We hear the Sound of Bodies, but little think of the Means by which the Senſe of Hearing is effected; nor do People in common appear concerned, to know the Reaſon of that wonderful Effect; though it be in a great Meaſure ſhewn very eaſily by the Air-pump.———For this Bell, which in the Air has ſo perfect, ſo loud, and ſo intenſe a Sound, will be found in the exhauſted Receiver to have none at all. ——— For being ſuſpended in this Piece of Braſs, I ſcrew it on to the Plate of the Pump. ——— Then, exhauſting the Air, and ſhaking the Pump, you ſee the Clapper ſtrike often the Side of the Bell, but hear no Sound in the leaſt.———Hence you are immediately convinced, that the Air is the neceſſary Means of Sound, and how it is ſo, I muſt take an Opportunity hereafter more fully to explain, when we come to Experiments, which more particularly relate to the Organs of Senſation.

Euphroſ. I ſhall ever think myſelf happy, to find my Underſtanding enlarged by Degrees, and as I ſee by this Experiment, that Air is neceſſary for Sound; ſo I preſume it is for Fire; ſince, by the Candle which I ſee here, I ſuppoſe, an Experiment of that Sort is intended.

Cleon. That is the Purport of the Candle:———For ſee; I light it, and place it under the Receiver,———and on the firſt Turn of the Winch, the Vigour of the Flame declines. ———Upon the ſecond or third Stroke, you obſerve, it declines by Degrees, and goes out. ——— I keep turning the Winch, and the Smoke, you obſerve, deſcends very copiouſly from the Wick, being much heavier than the rarified Air.——— Theſe are uſeful Documents, to acquaint us, how far the Air is neceſſary to ſupport a Fire and Flame.

Euphroſ. Every Experiment I have found, by Experience, a Leſſon of Inſtruction. I knew, that Fire much depended upon the Air being excited, and increaſed thereby at any Time; but was not before convinced, that it was ſo abſolutely neceſſary to its Exiſtence.———Pray, what means this Firelock, *Cleonicus*?

Cleonicus? I begin to have ſome Apprehenſions at the Sight of it.

Cleon. You need not be under any Concern about that. ——Your Maid every Day ſets fire to her Tinder, and lights her Candle by that Inſtrument; and you know, that the Means, by which ſhe does this, are the Sparks of Fire, produced by the ſtriking of the Flint againſt the Steel; but, when I place it under the Receiver, no ſuch Sparks appear.——This, you ſee, by the Experiment, ſeveral Times repeated.—— You ſee no Sparks, and therefore no Tinder can be kindled in *Vacuo.*——By all which, you learn how neceſſary the Air is even to the very Appearance of Fire.——There is one Experiment more, which is uſually ſhewn in Confirmation of this Doctrine, and that is, the letting fall ſome Gun-powder on a heated Iron in *Vacuo*, to ſhew there will be no Exploſion.

Euphroſ. The very Mention of Gun-powder makes me ſhudder. I hope, there will be no Danger attending this Experiment; if there be, I muſt prepare to get as far from the Pump, as the Limits of the Room will permit.

Cleon. I ſhall ſhew you no Experiment, where there is the leaſt Poſſibility of your being hurt by it: The Apparatus is every Way ſecure. —— You ſee a ſmall Magazine of Powder, lodged in the upper Part of this large Receiver, through which there paſſes a ſmall, hollow, Braſs Tube, with Holes in its Sides; as this is moved up and down in the Powder, a few Grains will get into the Tube, and fall from thence into the Bottom of the Receiver.——Then obſerve, this heated Iron is placed upon a ſmall Iron Tripod, and in the Air, I drop a few Corns of Gun-powder on it.——They immediately take fire, flaſh, and explode; but not ſo in *Vacuo.*——I take the ignited Iron, and place it on the Frame of the Pump, and cover it with a Recipient. —— And now, obſerve, upon my puſhing down the Wire, a little of the Powder falls from the Magazine upon the Iron, by the Heat of which they are melted, diſſolved, and evaporated, without any Appearance of Flaſhing, or Exploſion; and all, you obſerve, proceeds from the Want of Air.——I turn the Vent-ſcrew, and let in the Air, and then the falling Grains of Powder take fire from the Iron, and flaſh as before.

Euphroſ. Well, this Experiment has almoſt put me in a Tremor; and to tell you the Truth, I ſhould be glad to take a little Turn in the Garden, to take the freſh Air; beſides, I think it high Time, that you had a little Reſpite from the Fatigue of this Lecture; let us purſue the Remainder of theſe Experiments To-morrow, or the firſt Opportunity you have Leiſure.

DIALOGUE XIII.

The Experiments *on the* AIR-PUMP *continued.*

Euphroſ. I Hope your exploſive Experiments are now at an End; for though I take Pleaſure in learning the Nature and Properties of the Air by them; yet they have ſo much of the Terrible in them, that I can ſcarcely conceit I am ſafe while you ſhew them.

Cleon. Our Paſſions are given us to a very good Purpoſe; they are a Kind of Armour to the Mind, and defend and fortify us againſt diſaſtrous Events: Others operate upon us in a different Manner, moving Pity and Compaſſion towards every Object we ſee in diſtreſsful Circumſtances; and this I am ſure will be your Caſe in the next Experiment.

Euphroſ. I am jealous of ſome baneful Experiment to follow. It gives me Pain to hear you prelude to it thus.——I thought the Life of ſome Animal was in the Caſe. —— See here comes *John*, with a lovely, young Rabbit. —— I hope, that tender Creature is not to be ſacrificed for my Sake.——

Cleon. You are like all the Reſt of your Sex. —— You think it Cruelty to attempt the Life of a large Animal, but are quite regardleſs of the Deſtruction of thoſe which expire under your Feet in every Walk of Pleaſure you take. —— We know not but the Life of one Animal is equal to that of another: Little depends on the Bulk or Size of the Creature: If any Thing, it is an Argument againſt you, to ſay it is ſmall; ſince all our Obſervations convince us, that whatever relates to animal Life, Senſation and Motion, is always more exquiſite in thoſe Creatures, in Proportion as they are ſmaller.——The Million of Mites in Cheeſe, of Eels in Vinegar, which are daily ſacrificed for your Appetite's Sake, do not move your Commiſeration ſo much, as this one ſingle Rabbit, that can hardly be ſaid to be more than half alive, and ſenſible, as being ſo young: —— But to mitigate your Concern, I ſhall only ſhew, in this Experiment, that the poor Creature does really depend upon the Air for Life; and after that, I ſhall put it into your Hands, as well as you ſee it now.——Here, *John*, put the Rabbit under the Glaſs. —— And now, my *Euphroſyne*, have a good Heart, and look on; for turning away your Face will boot the Animal nothing.——See, upon exhauſting, how uneaſy it appears.——As the Air is more rarified, the Animal is rendered more thoughtful of his unlucky Situation, and ſeeks in vain to extricate himſelf. —— He leaps and jumps about.——A Vertigo ſeizes his Brain.——He falls, and is juſt upon expiring. —— But I turn the Vent-piece, and let in the Air by Degrees.——You ſee him begin to heave, and pant.——At length, he rouzes up, opens his Eyes, and wildly ſtares about him.——I take off the Receiver, and ſhall now deliver it as recovered from the Dead.

Euphroſ. Poor, innocent Creature! I am grieved to think thou haſt ſuffered ſo much on my Account; but be aſſured, my Care ſhall be proportionably increaſed for thy future Safety and Welfare. Thou ſhalt always be my darling Rabbit; as by thee, I have been obliged to learn how neceſſary the Air is for animal Life, and Reſpiration. —— And, pray, *Cleonicus*, are theſe Fiſhes, which I ſee in this Jar of Water, deſtined to the ſame Fate?

Cleon. Not intirely, but partly ſo. The Fiſhes which you now ſee friſking about at the Bottom of the Water, will, when they are placed under the Receiver, be obliged to aſcend from the Bottom to the Surface; and though, at the ſame Time, they will ſhew a conſtant Endeavour to regain their former inferior Situation, they will never be able to do it. —— See the Experiment. As ſoon as I turn the Winch, they find the Difference of the Air.——You ſee the Bubble of Air aſcend from their Mouths and Gills. —— They appear uneaſy, and their Bodies are expanded. —— They continue to riſe, at the ſame Time, they ſhew an Endeavour to deſcend.——You ſee two out of the three floating on the Top, and though not in the Agonies of Death, yet they ſeem greatly diſtreſſed, and lie with their Backs downward, as it were, in an expiring Poſture, the Third is almoſt perpendicular, endeavouring to reach the Bottom, but cannot.——

Euphroſ. It is very diſagreeable to ſee thoſe poor Creatures in ſo miſerable a Plight, when probably their Condition may be worſe than that of Death. I have often obſerved the Air-bladder in Fiſhes; and I preſume, it is owing to the Expanſion of Air in thoſe Bladders, that they are thus obliged to ſwim. ——Pray, releaſe them from their Miſery, by letting in the Air.

Cleon. I will do as you require.——On turning the Vent-ſcrew, you obſerve, their Bodies, as it were, contract, and by becoming leſs, they are rendered heavier, and by that Means able to ſink, which they do with great Precipitation. ——By this Experiment, you ſee how neceſſary the Air is, even for Animals that live in the Water, though they can ſhift with ſo ſmall a Degree of finer Air, that it is not eaſy to kill them in the greateſt *Vacuum* that can be made with the Pump; ſo far from it, that I remember Mr. *Hawkſbee* tells us, he let two Fiſhes ſtand a whole Week in *Vacuo*, and they ſeemed to be briſker and better at laſt than at firſt, when the Air was drawn from them.

Euphroſ. The Uſefulneſs of this Machine ſeems unlimited. What a prodigious Variety of Experiments are ſhewn thereby to explain the Nature of Things, and the important Properties of Air! What other Experiments remain, *Cleonicus?*

Cleon. Several, which it is proper you ſhould be acquainted with.——You have ſeen the very great Weight of Air ſeveral Ways demonſtrated, but one more remains, which will afford you ſome Pleaſure.——Theſe hollow, Braſs Hemiſpheres are put together with a Leather between them, and by Means of the Stop-cock ſcrewed into the Plate of the Pump, the Air is then drawn out of them, and by turning the Stop-cock, I prevent its returning again.——I hang them on to the Steelyard, and move the Weight upon the Beam, 'till ſuch Time it is ſufficient to ſeparate them.——This, you ſee, happens at the Number $127\frac{1}{2}$, which ſhews, that ſo many Pounds Weight are equal to the Preſſure of the Air upon the Surface of the Hemiſpheres; and this agrees with what I have formerly ſhewn, *viz.* that the Preſſure of Air upon every ſquare Inch is equal to 15 Pounds, there being 8 ſquare Inches and $\frac{1}{2}$ in the circular Area of one Hemiſphere.

Euphroſ. This appears to be a very nice and certain Way of meaſuring, by Experiment, the Weight of the Air.——— But beſides the Experiment you formerly ſhewed me of the Quick-ſilver riſing in the Barometer, by the Weight of the Air, I ſuppoſe you have other Methods of doing it by ſeveral Parts of the Apparatus I here ſee.

Cleon. You rightly judge of them, my *Euphroſyne.*——— I ſhall give you an ocular Demonſtration, that the Quick-ſilver is ſupported in the Tube of the Barometer, entirely by the Preſſure of the Air. Obſerve the following Proceſs.——— I take this ſmall Baſon of Quick-ſilver, and place it on the Plate of the Pump.——— Then I invert this Tube, filled with Quick-ſilver, therein.———I place a Receiver over them, and ———on the Top of that, a tall Tube cloſe on the Top.——— The Quick-ſilver is ſupported, you obſerve, to the Height of more than 29 Inches. ——— Then I turn the Winch, and by leſſening the Preſſure of the Air, on the Surface of the Quick-ſilver in the Baſon, it deſcends in the Tube. ——— A ſecond Stroke leſſens the Preſſure farther, and the Quick-ſilver deſcends ſtill lower. ——— A third, fourth, &c. promotes the gradual Deſcent;———'till at laſt, you ſee, the Tube almoſt evacuated, as the Quick-ſilver ſtands within but a little above the Surface of that in the Baſon; all which plainly ſhew the Thing propoſed. ——— But this is rather a negative Way of ſhewing the Thing.———You will ſee it poſitively and properly produced by the Preſſure of the Air, when I let it again into the Receiver. ——— I turn the Vent-ſcrew but a little Way, and the Air can get but very ſlowly in.———Then, you ſee, how naturally the Mercury riſes in the Tube, 'till it has attained its former Height, and thereby meaſure the total Preſſure of the Air.

Euphroſ. This is a very curious and full Proof of the Suſpenſion of Mercury in the Barometer, by the Preſſure of the

Air. ——— But what means this other Apparatus of a long Tube, ſcrewed into a Phial of Quick-ſilver?

Cleon. That is to ſhew how the ſame Effect is producible by the Spring of the Air. ——— For, you obſerve, the Air in the Bottle is confined, and cannot get out: ——— That the long Tube is open upon the Top, ——— and that therefore, when I cover the Hole with the Receiver, and tall Glaſs Tube as before, upon exhauſting the Air, and taking its Preſſure off the Surface of the Mercury in the ſmall Tube, the Spring of the Air in the Phial will exert itſelf on the Mercury there, and force it up into the Tube,———'till at length, having drawn away all the Air, the Mercury riſes to the ſame Height, by the Spring of the Air in this Caſe, as it did by its Preſſure in the other.

Euphroſ. A ſurpriſing Coincidence, and Equality of Effects, produced by the Spring and Preſſure of the Air!———Here ſeems yet another Inſtrument, compounded of ſeveral Parts, to the ſame Purpoſe; pray, what is the Uſe of that?

Cleon. It is partly to ſhew the ſame Thing as before; but more directly exhibits the Rationale of Pump-work, as it demonſtrates the Reaſon why, at every Stroke in the common Pump, the Water of the Well riſes in the Pipe below, 'till it arrives in the Ciſtern, and there runs out; ——— for the Braſs Syringe, or Barrel on the Top of the Receiver, repreſents the Barrel of the Water-pump.———The Mercury in the Baſon, the Water in the Well, and the Glaſs Tube, immerſed in it, ſhews the Pipe of the common Pump; ——— for now ſee the Experiment.———I raiſe the Piſton of the Barrel, and thereby lifting the Weight of the Air off from that in the Glaſs Tube, the Mercury begins to aſcend by the Preſſure of the Air on that in the Receiver; which ſhews how the Water riſes in the Pump by the ſame Means.———But now I place the Baſon of Quick-ſilver under the Receiver, and the Braſs Syringe on the Top, with the Tube immerſed in the Mercury as before,———and draw out all the Air.———Then I raiſe the Piſton, but no Mercury riſes in the Tube, as there is now no Preſſure of Air to produce that Effect.———From all which you are convinced, that the Medium of Air is the great

Agent employed to actuate all Kind of Machinery concerned in the Pump-work of every Sort.

Euphroſ. I fear I ſhall tire you before you have done; as I ſee there are many other Parts of the Apparatus yet unuſed; but as I learn ſo much from every one, I ſhall, for my own Sake, bear with your Fatigue a little longer.

Cleon. Say nothing of that, Siſter; for whatever improves your Mind gives me the greateſt Pleaſure. A few Experiments more will finiſh the uſual Courſe, and the next ſhall be of Fountains, which play by the Weight and Spring of the Air; —for this Purpoſe, I take this Transferer, or Plate of Braſs, with a tall Receiver on it, and by Means of a Stop-cock, ſcrew it to the Plate of the Pump, and exhauſt all the Air.—Then I take it off the Pump, having firſt turned the Stop-cock to prevent the Return of the Air to the lower Part, I ſcrew on a Glaſs-tube, and then place it in a Baſon of Water.—After this, I turn the Stop-cock, and the Preſſure of the Air, on the Surface of the Water, forces it up, through a very ſmall Adjutage in the Plate, in the Form of a curious Fountain, to the Top of the Glaſs, from whence it deſcends to the Bottom, and thus it will keep playing, till the Water riſes to the Hole in the Top of the Adjutage.

Euphroſ. This is a very entertaining Experiment; but how do you apply the Apparatus to make the ſame Fountain by the Spring of the Air?

Cleon. Nothing more is neceſſary for this Purpoſe, than ſcrewing the Stop-cock, with its Pipe, on a Bottle, partly filled with Water;—for this being done, when I turn the Stop-cock, the Spring of the included Air drives the Water thro' the Pipe into the exhauſted Receiver, and plays the Fountain, as before.

Euphroſ. I think you call theſe artificial Fountains; and ſurely they deſerve that Epithet.——I have heard much talk of the Experiment of the Guinea and Feather falling at the ſame Time to the Bottom of a Receiver in *Vacuo*. I ſuppoſe this tall Receiver is appropriated to that Uſe.

Cleon. It is ſo; and by this ſmall Machinery of Braſs, you ſee, it is very eaſy to let the Gold and Feather fall both at the ſame Inſtant from the Top.——I do this, while the Air is in the Receiver, and you ſee a manifeſt Difference in the Time of the Fall; the Feather deſcending gently, and with an indirect Motion to the Bottom.——But now I will replace them on the Top, and exhauſt the Air, and then,——look ſteadfaſtly at the Bottom of the Glaſs, and you ſee they both come there together.

Euphroſ. I obſerve they did; nor do I much wonder at it, when I conſider the great Reſiſtance that light Bodies meet with from the Air, but ſtill I cannot ſay, that, ſuppoſing there were no Reſiſtance at all, I clearly comprehend the Reaſon why a light Body ſhould fall ſo ſoon as a heavy one; for Bodies fall by their Weight, and there is much more Weight in the Guinea, than in the Feather, and therefore, one would naturally think, it ſhould fall ſooner.

Cleon. Moſt People think as you do, that the Velocity of falling Bodies is proportioned to their comparative Weights; but this is entirely a Miſtake; for the Velocity is proportioned to the Force of Gravity on a ſingle Particle of Matter in any Body, and this Force, being equal upon all the Particles, produces an equal Velocity in Deſcent upon them all; and whether they are more or leſs in Number, and whether they are connected or diſengaged from each other, does not affect the Caſe; for each Particle is ſtill impelled with the ſame Force; and therefore, one ſingle Particle, or any ſmall Number, will deſcend, juſt as faſt as any greater Number; which, in other Words, is only to ſay, that a light Body will fall juſt as faſt as a heavy one, in an unreſiſting Medium.

Euphroſ. I make no Doubt but what you ſay is right, and that I ſhall one Day or other be more capable of conceiving the Nature of thoſe phyſical Truths, better than I do at preſent; for now I chiefly attend to the Experiments, and ſhall, at my Leiſure, reaſon upon them in the beſt Manner I can by your Aſſiſtance. But, pray, what means the Chafing-diſh of flaming Charcoal juſt now brought into the Room.

Cleon. I ordered it not before, that it might not render the Air of the Room diſagreeable; for it is deſigned to ſhew what pernicious, and deadly Qualities it imparts to the Air, that is affected by it, and impregnated with its Fumes. We have but too many melancholy Inſtances of People, who are ſuffocated, and killed by ſuch a noxious and poiſoned Air, owing entirely to their Ignorance, how far the Air may be altered, with regard to its ſalubrious Property, by ſuch Parts as it receives from ſubterraneous Fermentations, mineral Strata, and vitiated Air, paſſing through them. This we uſually illuſtrate by the Air, paſſing through a Charcoal Fire, into the exhauſted Receiver, in the following Manner.——I take a large, open Receiver, and place on the Pump, on which is placed a braſs Plate, with a Stop-cock, and Crane-neck Tube of Copper.——Then, exhauſting the Air from the Receiver, and holding the Chafing-diſh of Coals, ſo that the End of the Tube may enter into a Part that is thoroughly kindled,——I turn the Vent-piece, and you hear the Air ruſh thro' the Fire into the Receiver.

Euphroſ. That I did, indeed.——But I ſee no Difference in that Air in the Receiver, and the common Air. I ſhould not have ſuſpected, that any Alteration had been made in the Air from what I ſee, in its paſſing through the Fire.

Cleon. But you will ſoon be convinced, there is a great Alteration made by that Means; for by putting a tender Bird, or other Animal, into the Receiver, filled by this Air, you would perceive it ſoon become ſtupified, afterwards convulſed, and at length expire; but ſuch Sort of Experiments would give you more Pain than Pleaſure: And therefore, I ſhall forbear them. It will be ſufficient to ſhew you, that a Candle will immediately go out in this corrupted Air; for ſee the Experiment.—I place the Candle on the End of the Wire, and put it down thro' the Top of the Receiver, but you obſerve, as ſoon as the Flame deſcends, without leaving it floating on the Surface, it becomes extinct.——I try it a ſecond Time, and it goes out as before; and this would be the Caſe, were I to attempt it an hundred Times.——I now let out a Part of the Air, by lifting the Receiver up, and let the Air from above force Part of it out from below.——Then I light up the Candle, and putting it down the Receiver, the Flame will ſoon appear to be affected,——is diminiſhed by Degrees,—looks blue,——and at Length, is extinct.——I will now light it up again, and ſhew how this noxious Air may be purified by Fire;——for this Purpoſe, I gently carry the Flame of the Candle thro' all the upper Parts of it, which it heats by Degrees, renders it by that Means lighter, and therefore, eaſily expelled by the Weight of the external Cold, and heavier Air; in this Manner it will ſoon be driven out of the Receiver, while you ſee the Flame of the Candle recover by Degrees; and burn at laſt with its uſual Vigour.

Euphroſ. Such Experiments as theſe are calculated, I find, not only for Entertainment, but are of the laſt Importance and Neceſſity. Ignorance in natural Science is not only always ſhameful, but in many Caſes extremely fatal. How many Lives might have been ſaved, and Families preſerved from Miſery and Ruin, had this one ſingle Experiment of the Air-pump been known to the Populace of every Age and Nation.

Cleon. Your Reflections on this Head are very juſt and rational; but tho' Providence has reſerved thoſe very great Diſcoveries for this Age, we ſeem to be little regardful of them, or grateful for them; nor, as we receive the Benefits intended by them ſo generally, as might be expected. For Inſtances of Mortality of this Kind, by Damps in Mines, Effluvia, *&c.* are but too numerous and recent among us; when almoſt every Gentleman of Taſte has an Air-pump in his Study. It would perhaps reflect too much on the Depravity of human Nature, to obſerve, with what Coldneſs, not to ſay Contempt, the moſt ſtriking and entertaining Experiments of the Air-pump have been treated by ſome People.——I have only one Experiment more to detain you with at preſent. You have been, doubtleſs, amuſed, with obſerving the *Halo* about the Moon, in a hazy Atmoſphere, in a Winter's Night.

Euphroſ. I have ſeveral Times obſerved that Phænomenon, not only about the Moon, but about the Sun. Pray, *Cleonicus*, can you explain the Nature of it, by any Experiment on the Air-pump?

Cleon. We can partly illuſtrate its Nature this Way; for it reſults from ſuch a Refraction of the Rays of Light, as is made by their Paſſage thro' a Body of Vapours and Air, of a particular Denſity, as you will eaſily obſerve by the following Experiment.——I take a Candle, and place it on that Side of the Receiver oppoſite to you, ſo that the Flame may be ſeen thro' the upper and larger Part: I then turn the Winch, and exhauſting Part of the Air, make it of a proper Denſity, and, at the ſame Time, filling it with Vapour, or aqueous Particles, from the moiſtened Leather below; the Effect will be, that the Rays of Light, paſſing from the Candle thro' this Medium-Air in the Receiver, will cauſe the Appearance of *Halos* round the Candle to your Eye, of different Colours and Extent——variable, as I make the *Vacuum* greater or leſs.——If I take the Air quite away, they diſappear, as they do alſo, by letting the Air in again.

Euphroſ. They make a beautiful Appearance indeed!——I obſerve them vary in their Colour and Magnitude, according to the different Denſity of Air, and Quantity of Vapour it contains.——From thence I am convinced of the general Nature of ſuch Appearances.—Upon the Whole, *Cleonicus*, however lightly others may paſs by theſe great Topics of natural Knowledge, I ſhall, for my own Part, ever reflect on them with the greateſt Pleaſure, and think myſelf indebted to you for the Pains you have taken to lay them before me in ſo inſtructive a Manner; and nothing will appear ſo aſtoniſhing to me, as to hear any Gentleman of Fortune, Spirit, or Genius, ſhould be without an Air-pump in his Poſſeſſion.

DIALOGUE XIV.

The Nature, Structure and Uſe of the CONDENSER, MERCURIAL GAGE, AIR-GUN, *and* VENTILATOR.

Cleon. THIS Morning, my *Euphroſyne*, finiſhes our Converſation on Pneumatics; for tho' you have ſeen a Variety of different Kinds of Machines for explaining the Nature and Qualities of the Air, there ſtill remain ſome, whoſe Uſes are too conſiderable not to deſerve your Notice. Thoſe you have already contemplated, chiefly regard the Weight and Spring of the Air in its natural State. But it will be worth your While to conſider how far the Spring of the Air may be increaſed by artificial Compreſſion, and the great Effects that are thereby produced.

Euphroſ. This is a Subject that will prove very grateful to me, provided you have nothing dangerous in theſe Sort of Experiments; for I have learned to know, by what has already paſſed, how very great Effects may be produced by the Spring of the Air, and I ſee ſome Parts of your Machinery here are particularly calculated againſt ſo great a Force: Pray, what do you call this Machine which ſtands here? *

Cleon. It is commonly called the CONDENSER, becauſe by Means thereof, the Air may be compreſſed almoſt to any Degree we pleaſe; for the two braſs Cylinders, being placed together with a Leather between them, and ſcrewed faſt upon each other in the Frame, as you ſee, the Air thrown in by the Piſton on the Top, till it is rendered ſo denſe, and its Spring of Courſe ſo great, as we judge the Strength of the Braſs will admit. This is done, by placing the Valves in the Barrel and Piſton the contrary Way, to what you obſerved in thoſe of the Air-pump; for as they opened upwards, theſe open downwards, by which Means the Air that is crouded into the Condenſer cannot poſſibly return, and thus Experiments may be ſhewn on Animals, Vegetables, Fire, and any Sort of Subject included in this condenſed Air. Mr. *Boyle* has left us a great Number of Experiments on this Subject, by which he has ſhewn, that Animals may be killed by a too great Condenſation of Air;——that when condenſed to a moderate Degree, he has found them to live longer than in common Air.——That compreſſed Air affected Flies, Frogs, and ſuch like Animals but very little.——That Mouldineſs is promoted nearly in Proportion, as the Air is condenſed.——That Vegetation is not prejudiced by condenſed Air;——and many other Things of Conſequence you will find in his Treatiſe on this Subject, to which I refer you.

Euphroſ. I ſee but one Objection to this Machine, and that is, one loſes the Pleaſure of ſeeing the Experiment in a great Meaſure, by the Subject's being included in a Veſſel of Braſs.

Cleon. The braſs Condenſer is uſed only in ſuch Caſes where great Degrees of Compreſſion are required, in all other Caſes a ſtrong Glaſs;——ſuch as you ſee here. †——In this you place the Animal, Plant, *&c.* and then condenſing the Air upon it with the Syringe, as before, you will have the Satisfaction of obſerving the Proceſs, and plainly ſee the Effects which condenſed Air has upon different Subjects placed therein.——In this glaſs Condenſer you may venture to force the Air in ſo far, as to render it three or four Times more denſe than the common Air, which will be ſufficient to anſwer moſt Purpoſes.——Moreover, you may at any Time know how denſe the Air is, by a ſmall mercurial Gage, placed in the Condenſer, and which

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* *Figures of Plate* XXXIII. *deſcribed.*

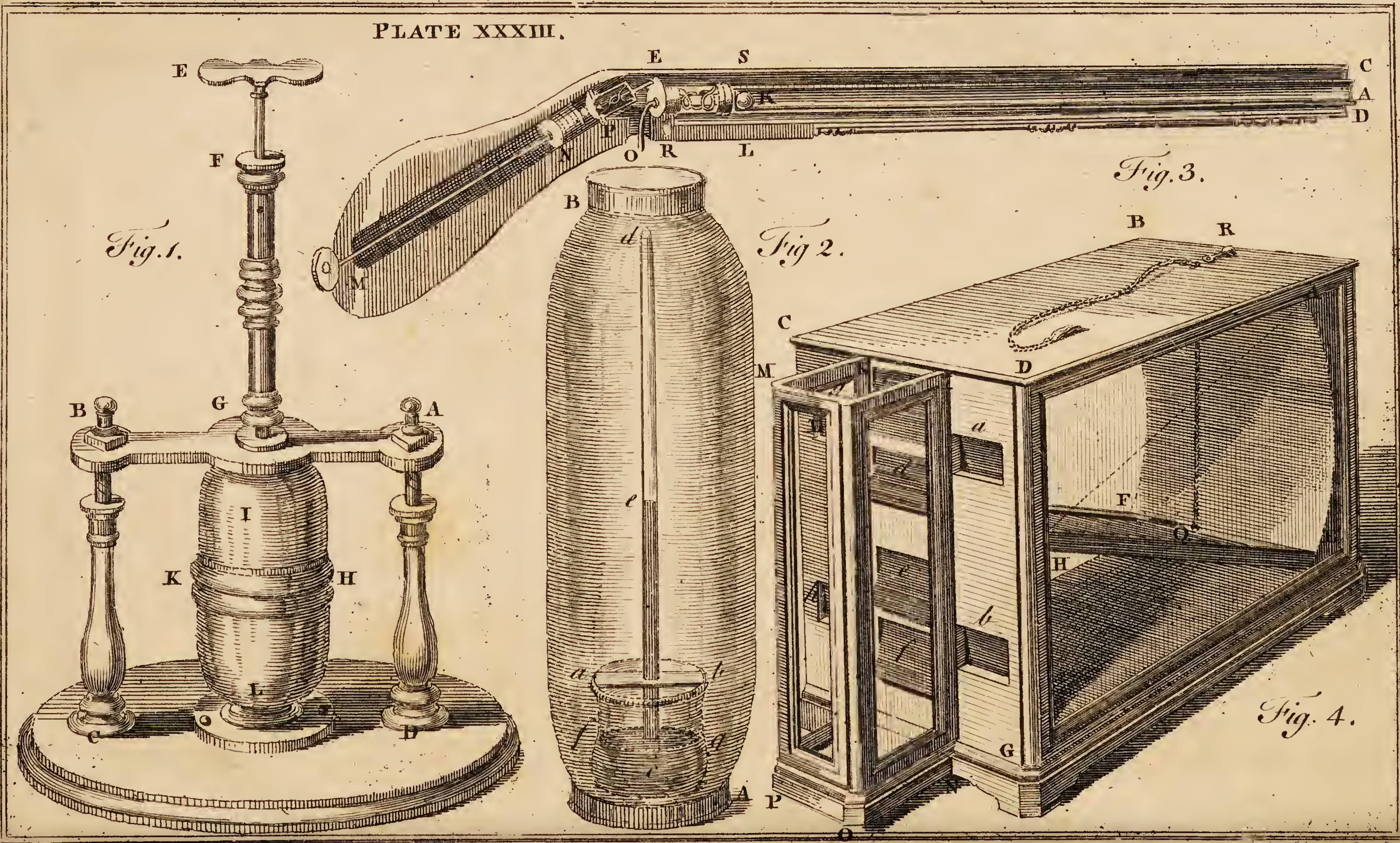
A B C D, The Frame of the Condenſer.——H I K H L K, The two Braſs Cylinders, or Parts ſet together at H K.——F G, The Braſs Barrel, or Syringe.——E, The Handle of the Piſton, by which the Air is injected.

† *Figure* II.

A B, The Glaſs Condenſer.——*a b c d*, The Mercurial Gage.——*a b c*, The Baſon.——*f g*, The Surface of the Quick-ſilver in the Baſon.——*c d*, The inverted Glaſs-tube.——*e*, The Surface of the Mercury in the Tube.

The CONDENSER, AIR-GUN and VENTILATOR.

PLATE XXXIII.



A. Walker Sc.

which I have provided on purpoſe to ſhew you the Experiment; for the ſmall Tube being inverted in a Baſon of Quick-ſilver, you will obſerve,——that as I force the Air into the Glaſs, it condenſes the included Air, and preſſing with a greater Force, drives it by Degrees up into the Tube,——and higher than before at every Stroke of the Piſton.———When the Quick-ſilver fills half the Tube, the Air is of a double Denſity,—when it fills $\frac{2}{3}$ of the Tube, the Air is three Times denſer, and ſo on; for the Denſity of the Air is always inverſely, as the Space it takes up, as you will eaſily underſtand.

Euphroſ. This will be the natural Reſult of Compreſſion in any Body.——But, pray, *Cleonicus*, what is the Deſign of this Gun?—I remember you told me, our exploſive Experiments were at an End, if ſo, why then this Fire-lock?

Cleon. It is a Gun, in Form like others, and has a Lock, but neither Fire nor Powder is here neceſſary.—The Method of diſcharging this Gun, is by Means of condenſed Air let in behind the Ball in the Barrel, and therefore it is called the *Air-gun.* ——This Gun conſiſts of two Barrels, and the Air is ſtrongly condenſed between them, by Means of a Syringe placed in the Butt-end.——But that you may have a more perfect Idea, I ſhall take the Gun to Pieces, and ſhew you the ſeveral Parts. ‡

Euphroſ You are very obliging, *Cleonicus*, the View of ſuch a Piece of Mechaniſm gives me the greateſt Pleaſure.——But when you diſcharge it, let me get at at a Diſtance from you.————

Cleon. You have nothing to fear.—Obſerve the Board at the Diſtance of 30 Yards.——I draw the Trigger;——The Bullet you ſee has paſſed thro' the Board,—and beat a Hole in the Brick of the Wall, ſeveral Yards behind it;—another Diſcharge, with the ſame Air, has the ſame Effect;——a Third carries the Bullet thro' the Board, as at firſt.———

Euphroſ. Well, this is a philoſophical Method of ſhooting, truly!—I could not have thought the Strength of Air had been ſo near to that of Gun-powder.—But ſee, what is this other curious Machine in Glaſs?

Cleon. You have often heard talk of Ventilators, for diſcharging the noxious Air from cloſe Rooms, in Priſons, on board a Ship, *&c.* and I have here a Model of one in Glaſs ‖, that you may plainly

‡ *Figure* III. *explained.*

C E M D, The Air-gun. ——— A K, The Barrel for the Bullet. ——— E C D R, The larger Barrel containing the Air.———M N P, The Syringe in the Stock of the Gun. —— E P, The Valve thro' which the Air is driven from the Syringe into the Space between the Barrels.———K, The Bullet lodged in its proper Place.—————S L, Another Valve, which being puſhed open by—— O, the Trigger, lets the condenſed Air in upon the Bullet, which drives it out with very great Force.

‖ *Figure* IV.

A B C D E F G, The Body of the Glaſs-ventilator. —— I K L M N O P, The Glaſs-caſe in Front. —— F H, A Board that moves up and down.——Q R, The String by which it is moved. ——— a g, The two Valves in Front at Top, by which the Air enters into the Ventilator.———*c d*, Two Valves, by which the Air goes out of the upper Part into the Glaſs-caſe.—————*b h*, Two Valves in the lower Part of the Ventilator, by which the Air of the Room enters into it. —————*e f*, Two Valves, by which the Air is forced out of the lower Part into the Glaſs-caſe.

ly ſee its Nature, and Manner of Operation.—You obſerve the Body of the Machine is a Box, within which a Board is hung to the Middle of the Fore-part, and is moveable backward and forward, from the Bottom to the Top, as the Hinder-part, and by Means of Leathers on its Sides and End, is ſo exactly adapted to the internal Cavity, as to ſuffer little or no Air to paſs by it, as it moves up and down. —You move it upward by the String, and a Plate of Lead carries it down again to the Bottom.

Euphroſ. Pray, let me work this Machine.——It moves up and down very eaſy.———But what are thoſe Leathers in the Fore-part, which move ſo quick one Way and the other, while the Machine is in Motion.

Cleon. They are the Valves, which perform the Office of thoſe in a Pair of Bellows; for when the Board is lifted up, the Air ruſhes into the lower Part, thro' two Valves placed in Front,——and at the ſame Time it is driven out of the upper Part, thro' two Valves into a Glaſs-caſe, fixed in the Front of the Machine.—Again, when the Board deſcends, the Air ruſhes in thro' two Valves in the upper Part, which open inward, while that below is driven out of the Box into the Glaſs-caſe, by two other Valves below:——Wherefore you will eaſily underſtand, that by making an Aperture in the Window, or Side of the Room, to fit the ſaid Caſe, or a cloſe Tube coming from any Part of it, that then every Time the Board moves up and down, ſo much Air of the Room will enter the Ventilator, and be thrown abroad, as is juſt equal to Half its Capacity, or Bulk, and therefore, one may pretty eaſily know, at how many Strokes, and in what Time, the vitiated Air of any Room may be exhauſted, and the Room filled with that which is freſh and healthy;———and theſe are now ſo adapted for Uſe, that they may be applied to any Room in a Houſe, even in Gentlemens Studies and Bed-chambers, to a very good Purpoſe.

Euphroſ. I underſtand all you have ſaid very well, and do aſſure you, I like the Contrivance ſo well, that I deſign to get one for my own Uſe ————But my Time is expired, at preſent, having an Engagement the Remainder of the Forenoon; but ſhall be glad to know what Subject we are to enter upon at our next Interview.

Cleon. We have taken a Survey of the Heavens, and the Atmoſphere that ſurrounds the Earth, which naturally conducts us to contemplate the Figure of the Earth, and its various Phænomena, together with thoſe of the Heavens, which will bring us to the *Uſe of the* ARTIFICIAL GLOBES, which will be the Subject of our future Hours of Leiſure.

The End of the FIRST VOLUME.

INDEX.

A.

AIR defined 256
—— height of *ib.*
—— weight of *ib.* & 327
——— cauſe of its weight 257
——— heat and cold 337
——— preſſure 257
——— perceptible in ſome caſes, *ib.*
——— attraction and gravitation 258
——— repulſive force *ib.*
——— elaſticity *ib.*
——— denſity of 259
——— uſes of 271
——— motion of 272
Air bubble in eggs 375
Air in efferveſcent liquors 380
—— in free-ſtone *ib.*
—— in apples 381
—— in wood 385
—— in plants *ib.*
—— weigh'd in a balance 391
—— the medium of ſound 396
—— neceſſary to fire *ib.*
—— to the life of animals 398
—— preſſure and ſpring 402
Air-gage 365
Air-gun 409
Air-pump, invention of 357
——— beſt conſtruction 360
——— mechaniſm deſcribed 362
——— illuſtrated by a plate *ib.*
Armillary ſphere 172
——— plate of *ib.*
Aſcenſion, right, of the planets 186
——— ——— ——— ſtars *ib.*
Aſpects, lunar 93
——— at the earth *ib.*
Attraction, not effected by electricity 313
Autumn 231, 232
—— deſcribed by mr. *Thomſon*, &c. *ib.*

B.

BArometers, their uſe 327
——— beſt conſtruction 332
——— method of filling 331
Bellows, nature of 272
Bells rung by electricity 315
Beneficence in God infinite 251
Bird, killed by an electrical ſhock 312
Bladder, experiments of 372

C.

CHimnies, cauſe of ſmoking 272
Circles of the ſphere 171
Clouds variegated 281
——— thick and lowering *ib.*
——— height of 282
——— velocity computed 283
Cometarium 107
——— plate of *ib.*
Comets, their orbits 105
Compaſs, its uſe 178
Condenſer, its nature and uſe 408
Cupping explained 370

D.

D*Avenport*'s air-pump, print of 366
Day, cloſe of, deſcribed 247
——— different length 237
Day and night, theory of 243
——— alternately equal 250
Declination of the heavenly bodies 189
Dedication to his royal highneſs 3
Denſity of air 259

E.

EArth, a planet 55
Earth's lunar aſpects 93
Eclipſe defined 148
——— of the ſun 141
——— repreſented by a teleſcope *ib.*
——— by a ſcioptric ball *ib.*
——— ſhewn by a copper-plate *ib.*
——— central, what 153

Eclipſe, total of the ſun ib.
—— of the moon 154
Ecliptic 175
—— circles 188
Eggs, bubbles of air in 375
Elaſticity of air 258
Electricity, nature of 309
—— experiments of 324
—— eſſence 319
—— velocity 321
—— ſimilitude with lightening 323
—— applied to cure diſorders 326
Electrical fluid, action of 390
Equinoctial 175
Evening, ſummer 247
Exhalations, how produced 263
—— not viſible 264
Experiments on electricity 309—324
—— to ſhew heat and cold 264
—— to produce exhalations 265
—— to ſhew the weight of air 368
—— to ſhew the preſſure 370
—— to ſhew the ſpring 373
—— on the air-pump, from 368 to 388
—— of the guinea and feather 403
Experimentum crucis 269
Explanation of the figure in the plates XXXI, XXXII. 405
—— of plate XXXIII. 408

F.

FANS 271
Fire electrical 310
Fluid, electrical, luminous 313
Fountain plays by the weight and ſpring of air 403
Fogs, how generated 285
—— a denſer kind of vapour ib.
—— deſcribed by *Milton* 286
—— A rimy one ib.
Freezing a curious phœnomenon 281
—— exemplified by a plate ib.
Froſt, the black 286
—— the hoar, or white 287
Fruit, method of preſerving 383

G.

Globe, its uſe 173
Gold, leaf, attracted by electricity 323
Gold, leaf, repelled by electricity 323
Gravitation of air 258
Gun-powder, fir'd by electricity 316

H.

Hail 292
Hail-ſtones, form and ſize ib.
Halo about the moon 406
Harveſt-field 234
Harveſt-moon 237
Heat, cauſe of 227
—— the power of 264
—— and cold of the air 337
Heavenly bodies 189
—— latitude ibid.
—— longitude ibid.
Horizon 177
Hygrometers, uſe of 351
—— a print of ib.

I.

Introduction 1
Jupiter, a planet 72
—— his moons 128

L.

Latitude, degrees of 175
—— of the heavenly bodies 189
Limits of ſolar eclipſes 159
—— lunar ditto ib.
Longitude 207
—— how found by *Jupiter*'s moons 208
—— of the heavenly bodies 189

M.

Magnetiſm 388 & *ſeq.*
Man, killed by electricity 324
Mars, a planet 65
Mercurial ſhower 386
Mercury, proper for a barometer 340
—— for a thermometer ib.
Mercury, a planet 48
Meteors 278
Monſoons, what 274
—— cauſes of them ib.
Moons in general 114 to 126
Motion of air thro' bellows 272
—— in a ſtove ib.
—— in a chimney ib.
—— accelerated by electricity 313
Motions geocentric 88
—— heliocentric 86

INDEX.

N.

NIght 227
—— explained by the orrery ib.
Nonius, its uſe 336
Noon deſcribed 246

O.

ORRERY explained 173
—— ſtructure and uſes 199 & ſeq.
—— ſhewn by a plate ib.

P.

PHaſes of *Saturn*'s ring 220
Philoſophy, the buſineſs of ladies 262
—— a rational entertainment 253
—— part of the heavenly employ ib.
Plan of the Mag. from p. 1 to 11
Planetarium 85
—— ſtellated 89—95
Planets, right aſcenſion of 186

PLATES.

1 *Ptolemaic* ſyſtem 1
2 New planetarium 17
3 *Copernican* ſyſtem 22
4 Planetarium adapted to it 25
5 Solar ſyſtem ibid.
6 Wheel-work of the planetarium 27
7 Planet *Mars* 63
8 Geocentric planetarium 88
9 —— appendix thereto ib.
10 The ſtellated planetarium 89
11 Wheel-work of the cometarium 107
12 Sun enlightening the earth 111
13 Phaſes of the moon, &c. 119
14 *Saturn*'s ſatellites 128
15 Annual motion of the ſtars 143
16 Eclipſe of the ſun and moon 151
17 Limits of ditto 159
18 Armillary ſphere 172
19 The orrery 173
20 Phaſes of *Saturn*'s ring 220
21 The ſeaſons of the year 221
22 Summer-ſeaſon 227
23 Different length of day and night 238
24 Winter-ſeaſon 244
25 A new electrical machine 300
26 Triple weather-glaſs 330
27 Standard thermometers of *Newton* and *Farenheit* 346
28 Lord *Cavendiſh*'s ditto 349
29 Mr. *Hawkſbee*'s air-pump 363
30 { *Davenport*'s air-pump 373
{ Portable ibid.
31 Experiments on it 388
32 —— ditto 395
33 Condenſor, ventilator, &c. 408
Portable air-pump 360
Providence, proof of 284
Ptolomaic ſyſtem 11—16
Pump-work, the rationale of, ſhewn by the air-pump 402

R.

RAin 283
—— cauſes of it ibid.
—— regular deſcent of ibid.
Reflections on the univerſe 165
Repulſive force of air 258
Rural life deſcribed by *Homer* 235
—— by ſir *Richard Blackmore* 236

S.

SAnd electrified 309
Satellites of *Jupiter* 208
Saturn, planet of 78
—— his ring 215
—— his moons 216
—— moves in an eliptic orbit ib.
—— obſerves a paraliſm of poſition 213
Seaſons of the year 220
—— ſhewn by the orrery ibid.
—— deſcribed by *Ovid* 221
—— by *Virgil*, *Thompſon*, &c. 224
Shadow, the earth's 158
—— compaſs of the moon's 154
Snow, flakes of 288
—— cauſe of their chryſtallization ib.
—— form, ſhewn by a plate 289
—— illuſtrated by experiment ib.
—— deſcribed by *Homer*, *Broome*, 291
Solar ſyſtem 25
Solar and lunar eclipſes 159
—— the limits of each ib.
Solſticial colure 175
Sphere, diviſion of ibid.
—— different denominations 171
Spring deſcribed 223
—— by *Virgil*, *Pope*, &c. 224
—— appears in the vegetation of plants ibid.
—— influences the feathered kind ib.
Stars, their right aſcenſion 186
—— ſolar, argum. to prove them 138

Stars, their diſtance and magnitude 136
—— ſome appear conſtantly 142
—— ſome large, other ſmall 134
—— why ſome are fixed 132
—— number conjectured 140
—— cauſe of twinkling 146
—— differ from the planets *ibid.*
—— polar, moves round a point *ib.*
—— nebulous, 144
—— numberleſs 146
—ſome are extinct, new ones appear *ib.*
Summer-evening 247
—— ſeaſon 227
—— explained by a plate 228
Sun conſidered 34
—— riſing deſcribed 245
—— by *Virgil* *ibid.*
—— by *Garth* *ibid.*
—— by *Homer* *ibid.*
—— by *Thompſon* *ibid.*
—— ſetting deſcribed 246
—— by the orrery *ibid.*
—— by *Thompſon* 247
—— nature and cauſe of its eclipſe 148
—— illuſtrated by a plate *ibid*
Syringe and piſton deſcribed 392

T.

TAble of the earth's lunar aſpect 93
—— of the geocentric motions 88
—— of the heliocentric 86
—— of the eclipſes of the 1ſt ſatellite 210
—— their immerſions *ibid.*
—— their emerſions 210
Teleſcope invented and improved 215
Thermometer, nature and uſe of 337
—— different conſtruction 338
—— ſir *Iſaac Newton*'s ſtandard
—— *Farenheit*'s, &c. &c. *ibid.*
Tranſition from winter to ſpring 251
Triple weather-glaſs 330

V.

VApours 263 & 279
—— why they riſe in the air 280
—— appear under the form of clouds 281
—— variegated with colours *ib.*
Venus 48
Ventilator, of its parts and uſe 410
Univerſe, ſyſtems of the 7—11
—— reflections on its immenſity 165

W.

WEight of air 327
Winds; the doctrine of 271
—— their nature and uſe *ibid.*
—— their force 273
—— variable *ibid.*
—— of whirlwinds *ibid.*
—— the conflict of 268
Winter deſcribed 238
—— by *Homer* 239
—— by *Virgil* 240
—— by ſir *Rich. Blackmore* 241
—— by Mr. *Thompſon* 242
Worlds, plurality of 166